INSTRUCTION MANUAL

MULTILOGGER

SC-7501

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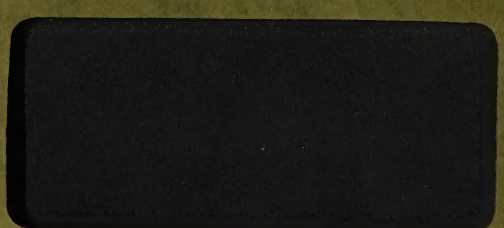

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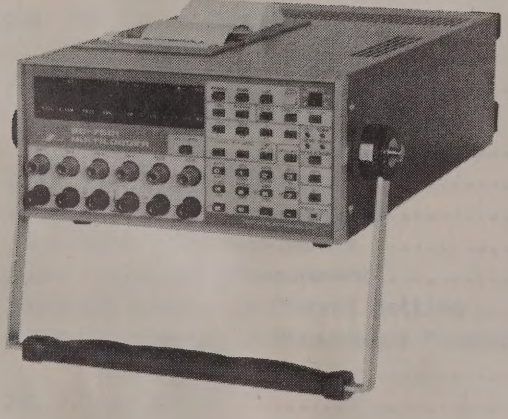

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MULTILOGGER

SC-7501

B406-516101 (L)

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Section 1 SPECIFICATIONS

The SC-7501 is a portable multi-logger with functions for measuring dc and ac voltages, resistance and temperature at 12 input channels, and for displaying and printing by a printer in the measured results.

Highly sensitive measurements can be performed in wide ranges from 1 μV to 270 V for dc voltage, from 10 μV to 270 Vrms for ac voltage at the true RMS value by the analog processing method, from 1 mΩ to 19.999 MΩ for resistance, and from -200°C to +1600°C for temperature by means of 5 kinds of thermocouples, respectively.

In addition to the various processings on the measured results, conditions for measurement and kind of processing to be performed can be set from the keyboard and the set data can be maintained by a battery-backed-up RAM for about 3 months even if the power is turned off.

An optional built-in GP-IB interface card permits connection with an external controller, which enables higher-level data processing.

1-1 MEASURING MODES

1-1-1 DC Voltage Measurement (CH1 to CH12)

Range	Accuracy (23±5°C, 80% RH or less)	Resolution	Maximum Display
20mV	±0.03% of rdg ±0.045% of range	1μV	19.999mV
200mV	±0.03% of rdg ±0.015% of range	10μV	199.99mV
2 V	±0.03% of rdg ±0.005% of range	100μV	1.9999 V
20 V		1mV	19.999 V
200 V		10mV	199.99 V
270 V	±0.03% of rdg ±0.04% of range	100mV	270.0 V

rdg : Displayed value
range : Value in the range column
*Accuracy means after adjusting zero by mV Ω ZERO ADJ.

Temperature coefficient
0°C to 18°C, 28°C to 50°C
20 mV range
(±0.003% of rdg ±0.002% of range)/°C
200 mV to 200 V range
(±0.003% of rdg to ±0.0005% or range)/°C
270 mV range
(±0.003% of rdg ±0.004% of range)/°C

Ranging
Auto and manual.

Zero Adjustment
Permitted in a range of ±2 mV by the switch on the front panel. (However, when the zero adjustment is performed, A/C converter full scale value is limited by that degree.)

Input Resistance
At CH1 to CH6
100 MΩ or more: 20 mV to 2 V range
Approximately 10 MΩ: 20 V to 270 V range
At CH7 to CH12
Approximately 1 MΩ: 20 mV to 270 V range

CMR
115 dB or more (1 kΩ unbalance resistance, 50/60 Hz ±0.1%)

NMR
50 dB or more (50/60 Hz ±0.1%)

Maximum Input Voltage
±270 V (Between HI and LO terminals)

1-1-2 AC Voltage Measurement (CH1 to CH6)

Sine Wave
(Input of 10% or more of the amplitude of the range)

Range (Resolution)	Frequency	Accuracy(23°C±5°C 80% RH or less)
200mV(10μV) 2 V(100μV) 20 V(1mV) 200 V(10mV)	45Hz to 100Hz	±0.8% of rdg ±0.2% of range
	100Hz to 10kHz	±0.3% of rdg ±0.15% of range
	10kHz to 30kHz	±0.4% of rdg ±0.25% of range
	30kHz to 100kHz	±0.8% of rdg ±0.55% of range
270 V (100mV)	45kHz to 100Hz	±0.8% of rdg ±0.6% of range
	100Hz to 1kHz	±0.2% of rdg ±0.6% of range

Temperature Coefficient 0°C to 18°C, 28°C to 50°C

Range	Frequency	Temperature coefficient
200mV 2 V 20 V 200 V	45Hz to 100Hz	(±0.04% of rdg ±0.01% of range) /°C
	100Hz to 10kHz	(±0.02% of rdg ±0.01% of range) /°C
	10kHz to 30kHz	(±0.02% of rdg ±0.01% of range) /°C
	30kHz to 100kHz	(±0.04% of rdg ±0.02% of range) /°C
270 V	45Hz to 100Hz	(±0.04% of rdg ±0.05% of range) /°C
	100Hz to 1kHz	(±0.02% of rdg ±0.05% of range) /°C

Ranging
Auto and manual
Conversion Method
Measurement of true rms value (Analog processing method)
AC or AC + DC coupling (Selectable by means of the switch on the rear panel.)

Crest Factor (Peak Value/True rms Value)
3 or less (at full scale)
Input RC
Approximately 1MΩ//400 pF or less
Maximum Input Voltage
270 V rms (Between HI and LO terminals)

Separation of Channels in AC Voltage Measurement
Separation between channels in CH1 to CH6.

Signal Source Impedance	Measured Frequency	
	1 kHz max	100 kHz max
600 Ω	85 dB or more	50 dB or more
1 k Ω	75 dB or more	40 dB or more

1-1-3 Resistance Measurement (CH1 to CH6)

Range	Accuracy (23°C±5°C ; 80% RH or less)	Measured Current	Resolution
20	±0.06% of rdg ±0.1% of range	10 mA	1m Ω
200	±0.04% of rdg ±0.02% of range		10m Ω
2kΩ	±0.04% of rdg ±0.015% of range	100 μA	100m Ω
20kΩ	±0.04% of rdg ±0.005% of range		1 Ω
200kΩ	±0.04%of rdg ±0.005% of range	10 μA	10 Ω
2MΩ	±0.08% of rdg ±0.005% of range	1 μA	100 Ω
20MΩ	±0.7% of rdg ±0.005% of range	100 nA	1kΩ

Temperature Coefficient
0°C to 18°C, 28°C to 50°C
20Ω to 2 MΩ range
(±0.004% of rdg ±0.0005% of range) /°C
20 MΩ range
(±0.02% of rdg ±0.0005% of range) /°C
Ranging
Auto and manual
Zero Adjustment
Permitted in a range of 2Ω by means of the switch on the front panel. (However, when the zero regulation is performed, A/D converter full scale value is restricted by that degree.)
Open terminal voltage
5 V or less
Maximum Input Voltage
±270 V DC
* Accuracy means after adjusting zero by mVΩ ZERO ADJ.

1-1-4 Temperature Measurement (CH7 to CH12)

Selects Type I or Type II

•Type I ROM (JIS C1602-1981, IEC854-1, ANSI MC96.1, BS4937)

Thermocouples

R, K (CA), T (CC), J (IC), and E (CRC).

•Type II ROM (DIN 43710-1977)

Thermocouples

R, K (CA), T (DIN), T (DIN), S

Linearization

Processing method by a microprocessor

Reference Point Temperature Compensation Accuracy

±0.5°C (Except R, S),±0.9°C (R, S)
(23°C ± 5°C, 80%RH)
±1.5°C
(0 to 50°C, below 60%RH)

Burn-out Detection

In case of 10kΩ ±5kΩ or more, it is detected as the breaking of the thermocouple.

Temperature Measurement (Type I ROM)

Thermo-couple	Temperature Range	Worst Resolution	Accuracy of Measurement (23°C±5°C; 80%RH or less)
R	0.0 to 1600.0°C	0.1°C	±0.2% of full scale ±4 digits
K(CA)	-200.0 to +1370.0°C	0.3°C(0 to 1370.0°C) 0.8°C(-200.0 to 0°C)	±0.15% of full scale ±3 digits (0 to 1370.0°C) ±0.5% of full scale ±8 digits (-200.0 to 0°C)
T(CC)	-200.0 to +380.0°C	0.1°C	±0.2% of full scale ±1 digits (-100.0 to +380.0°C) ±0.5% of full scale ±1 digits (-200.0 to -100.0°C)
J(IC)	-200.0 to +900.0°C	0.2°C(0 to 900.0°C) 0.5°C(-200.0°C to 0°C)	±0.2% of full scale ±3 digits (0 to 900.0°C) ±0.2% of full scale ±5 digits (-200.0 to 0°C)
E(CRC)	-200.0 to +1000.0°C	0.2°C(0 to 1000.0°C) 0.5"C(-200.0 to 0°C)	±0.2% of full scale ±2 digits (0 to 1000.0°C) ±0.2% of full scale ±5 digits (-200.0 to 0°C)

Temperature Measurement (Type II ROM)

Thermo-couple	Temperature Range	Worst Resolution	Accuracy of Measurement (23°C±5°C; 80%RH or less)
R	0.0 to 1600.0°C	0.1°C	±0.2% of full scale ±4 digits
K(CA)	-200.0 to +1370.0°C	0.3°C(0 to 1370.0°C) 0.8°C(-200.0 to 0°C)	±0.15% of full scale ±3 digits (0 to 1370.0°C) ±0.5% of full scale ±8 digits (-200.0 to 0°C)
T(DIN)	-200.0 to +380.0°C	0.1°C(-200.0 to +380.0°C)	±0.5% of full scale ±1 digits (-200.0 to -100.0°C) ±0.2% of full scale ±1 digits (-100.0 to +380.0°C)
J(DIN)	-200.0 to +900.0°C	0.2°C(0 to 900.0°C) 0.5°C(-200.0 to 0°C)	±0.2% of full scale ±3 digits (0 to 900.0°C) ±0.2% of full scale ±5 digits (-200.0 to 0°C)
S	0.0 to 1600.0°C	0.1°C	±0.2% of full scale ±4 digits

Cautions

Accuracy does not include accuracy of reference point compensation nor of thermocouple.

1-2 MEASURING FUNCTIONS

1-2-1 Printer

Printing System
Thermal type
Printing Speed
0.5 sec./line
Printed Contents
Time (maximum 23-hour 59-minute 59-second) Channel number, Data, Unit, Over-range, and Processing Contents, List (set parameters content), Comment (two four-digit figures entered from REM key switch)
Scan Measurement Print Mode (SCAN P. MODE)
Print OFF, Normal, Trend, Graph
Lifetime
Printing of one million lines
(Be sure to insert a recording paper and prevent empty operation.)
Recording Paper
Roll type thermal paper (TP50CE)
Paper width: 60 mm
Length : 30 m

1-2-2 Display

Display Element
LED
Display Digit
Channel number: 2 digits
Data : 5 digits
Maximum Display
19999 (A/D converter full scale)
99999 (Processor full scale)
UUUUU (In case of A/D converter over or processor over)
Alarm Display
Alarm Lamp lights up when the result of limit decision is NO GO and burn out.
Unit Display
Lamp indicaiton at dB, °C, mV, V, Ω, kΩ, MΩ.
Timer
Maximum display: 23-hour 59-minute 50-second (displayed in the unit of 10 sec.)
Gate
Lamp indication of starting measurement.

1-2-3 Clock

Maximum Time
23-hour 59-minute 59-second
Time Setting
Arbitrary time setting in hour, minute, and 10 seconds is available by key-switch(es) on the front panel.

1-2-4 Scanning

Interval
Can be set as continuous or in the range of 10 second to 23 hour 59 minute 50 second. However, when the measurement and printing take long, it transfers to the next interval after completion of the measurement and printing.

1-2-5 Measurement Operation

Scan Mode
Signals of designated channels are scanned and measured at interval time set by the scanning interval. (After the completion of measurement, monitor channel measurement is repeated.)
Channel Scan Speed (without data processing)
Approximately 110 mS
DC V and 200Ω to 200kΩ ranges
Approximately 130 mS
Temperature, and CH7 to CH12 scanning measurement.
Approximately 800 mS
20Ω range
Approximately 1.8 S
AC V, 2 MΩ and 20 MΩ range
Monitor Mode
Except during the scan, continuous measurement is performed at designated channel.
Manual Mode
Measurement and printing on the printer are performed only once when the MANUAL key is depressed at the designated channel.

1-2-6 Data Processing

Kind of Calculation

$\bar{x}\sigma$, dB, Δ%, ×, ÷, Δ

Method of Calculation

Measured value X and Y are calculated. Y is a measured data of the option channel or constant number set from the key-switch on the front panel.

Kind of calculation and the value of Y can be set for each channel.

Content of calculation

X.Y MATH	Content of calculation	Processing Time	Remarks
$\bar{x}$ σ	Xmin Xmax $\bar{x}$, σ	Approximately 6.5 mS (In case of measurement)	———
dB	$20\log_{10}(\frac{X}{Y})$	Approximately 100 mS	Effective only in case of AC V or DC V measurement Unit of Y is VOLT. Y ≠ 0 (X/Y)>0
Δ%	$\frac{X-Y}{Y} \times 100$	Approximately 30 mS	Y ≠ 0
×	X x Y		———
÷	$\frac{X}{Y}$		Y ≠ 0
Δ	X - Y		———

When the range is switched to AUTO (AUTO range), no processing except dB is performed. dB processing is displayed in dB, Δ% processing LED-displayed without unit, and printing in %, and other units depend on the set range.

1-2-7 Limit Detection

The measured results (or results of calculation when processing is performed) can be compared with either or both of HI-LIMIT value and LO-LIMIT value, and the result of comparison can be displayed on LED indicator (ALARM) and printed on the printer. HI.LO-LIMIT values and the decision function ON/OFF can be set for each channel from the key-switches. However, when the range switch is set to AUTO (AUTO range), limit detection is not performed.

Either HI or LO limit over allows the ALARM indicator to light up.

The mark ▲ is printed in the case of the printing HI limit over, or the mark ▼ in the case of the LO limit over.

1-2-8 Parameter Setting

Channel Setting

Measurement function range, kind of calculation, constant and limit detection can be set for each channel.

Same Parameter Setting for Plural Channels (COPY)

Content set for a designated channel can be copied to other channels.

Measuring Channel Range

In the scan mode, scanning measurement is executed between the first and last channel. First and last channels can be set arbitrarily from the key-switches. However, it should be made as the first channel number ≦ last channel number.

1-2-9 Parameter Holding

Preset parameters can be held by the battery backed-up memory against the power failure or power off upto for about 3 months, provided that the internal battery is fully charged. The battery is fully charged by turning on the power for about 50 hours.

When the power is turned on, the power failure time or power off time is printed, and thereafter the scanning and measurement operation is actuated without resetting. However, the clock does not work in the power-off state.

1-2-10 General

Display
7-segment, 10mm LED(red),
2-digit + 5-digit
Maximum Display
19999 (A/D converter full scale)
99999 (Processing full scale)
A/D Conversion Method
Drift compensated integration
Printing Method
Thermal type
Measuring Channels
12 channels: CH1 to CH6 : DC V, AC V and resistance inputs
CH7 to CH12 : DC V and temperature inputs
Power Supply
AC 100/115/220/230/240 V ±10%
Power Consumption
Approximately 13 W (In AC operation without printer operation)
25 W or less (In AC operation with printer operation)
Maximum Input Voltage
100 V DC (Between Lo and guard)
270 V DC (Between guard and case)

1-3 PHYSICAL CHARACTERISTICS

Weight
Approximately 5.5 kg
Dimensions
(210 ± 2)W x (100 ± 2)H x (350 ± 2)L
(in mm)
(See Figure 1-1)

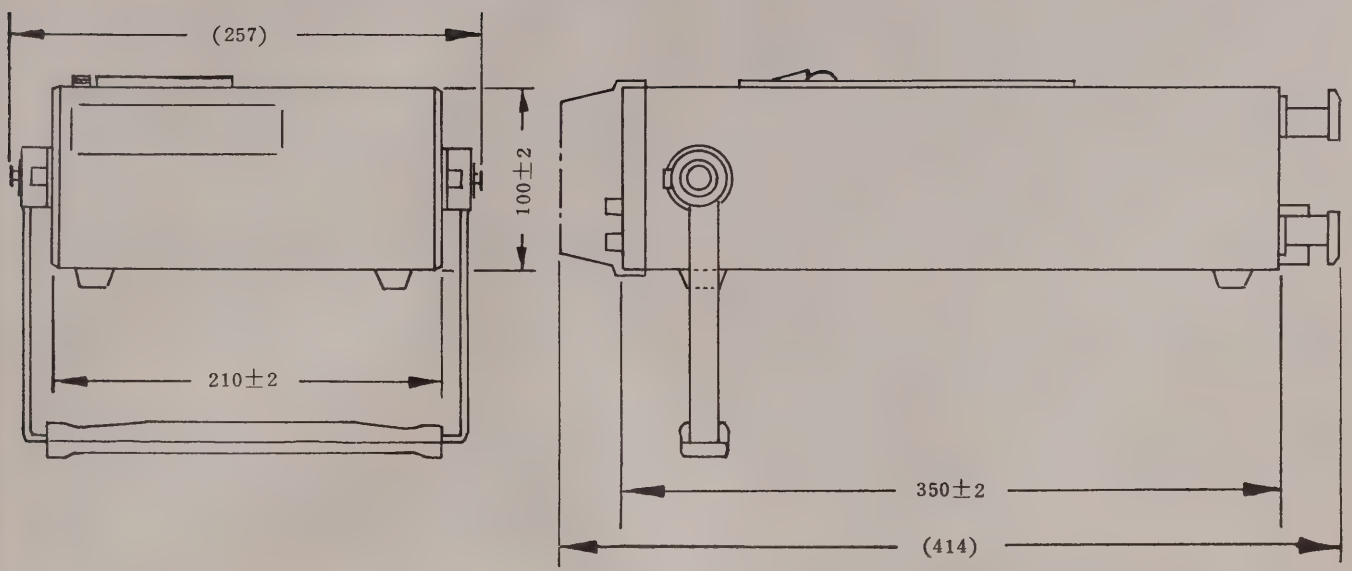
1-4 ENVIRONMENTAL CHARACTERISTICS

Operating Temperature
0°C to 50°C
Operating Humidity
80%RH or less (0°C to 40°C)
60%RH or less (40°C to 50°C)
Accuracy Guaranteed Temperature and Humidity
18°C to 28°C ; 80%RH or less

1-5 ACCESSORIES

Power cord	(1)
Cable for high resistance measurement	(1)
Fuse	(2)
Recording paper (TP 50 CE)	(2)
Panel cover	(1)
Dust cover	(1)
Accessory bag	(1)
Instruction manual	(1)

Figure 1-1 Dimension



Section 2 OPERATING PROCEDURE

2-1 PRECAUTIONS

Use care to the following items in operating this instrument.

Check the used supply voltage.

Voltage range is selected by voltage selector on the rear panel. Make sure that the supply voltage is within this range before connecting the power cord.

Check the ambient temperature of this instrument.

Ambient temperature suitable for normal operation of this instrument ranges from 0°C to 50°C. Be sure to use the unit within this range.

Ground the chassis

In order to prevent dangers by unexpected troubles including faulty insulation, ground the unit by using the grounding terminal on the rear panel.

Do not apply a excessively high input voltage.

Maximum input voltage for each input is as follows. Do not apply the voltage more than this.

Between LO and HI	270 V (DC + AC peak)
Between LO and guard	Maximum 100 V DC
Between guard and case	Maximum 270 V DC (Provided that the LO and the guard are short circuited.)

Use the specified fuse for replacement.

In order to prohibit overcurrent from the causing the damage to circuits, this instrument uses 0.5 slow blow fuse in the fuse holder inside the set. When the fuse is blown out, investigate the reasons therefore, and repair the troubles if any, and thereafter be sure to change with the specified fuse. Never use anything but the specified one, or it will cause failts, and dnager. Also, be sure to plug out the power cord from the set before replacing the fuse.

Internal battery charging

This instrument can store the conditions for measurement set by the setting keys for about three months by means of the internal battery even if the power is turned off. When this power for about 50 hours once about three months. When the power is turned on, this instrument performs easy self-checking and prints the power on time before starting the measuring operation. When an error occurred in the self-checking a numeral from 1 to 5 is displayed on the numeral indicator LED, and the operation stops. After the power is turned on, when the operation is kept stop or the time is not printed on the printer even if waiting for about 10 sec. has passed since the power was turned on, some troubles may have occurred, so contact our service personnel.

In particular, if the operation stops, displaying "3" on the LED indicator, it may be caused by the error that the battery for backing up the set parameters has been completely discharged. So, turn on the POWER ON UNIT switch on the rear side of the instrument, and turn on the power once again.

Precautions in using the stand.

This instrument can be used with the stand even folded as well as standing up. When using the stand in the standing state, remove the lock at the rotary parts (right and left) of the stand, and thereafter be sure to lock again.

When using this instrument in the standing states.

This instrument can be used in the standing position (facing the front panel upwards) in addition to the above mentioned. In this case, be careful not to turn down the unit by strongly pulling the lead wire for measurement.

Check 50 Hz/60 Hz switch selection.

Before starting to operate this instrument, set SI 50 Hz/60 Hz according to the commercial power supply frequency in your area (50 Hz area or 60 Hz area). (See Figure 2-1.)

Dirt on the front panel.

When the front panel gets dirty, never try to wipe it out with thinner or the like. When it becomes dirty, be sure to wipe it out with a soft cloth containing alcohol, alkaline detergent, or a volatile oil.

2-2 HOW TO REMOVE THE COVER

When setting the switch S1 inside of the instrument according to the commercial power supply frequency in your are (50 Hz area or 60 Hz area), or when inspecting the performance or performing

the calibration, it is necessary to remove the cover from this instrument.

Following is the procedure of removing the cover:

1. Remove the recording paper installed on the printer. (Refer to the later described "How to Remove the Recording Paper".)
2. Remove 6 screws fixing the upper cover at the right and left sides, and remove the upper cover trying to slightly widen the right and left side covers with your both hands. (The handle also will be removed at the same time.)
3. Lower cover can be removed by removing 3 screws.

Figure 2-1 50 Hz/60 Hz Change-over Switch

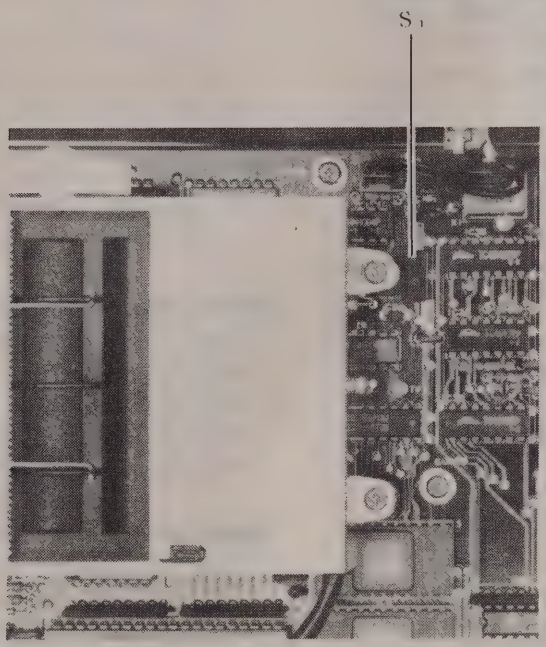


Figure 2-2 Front Panel

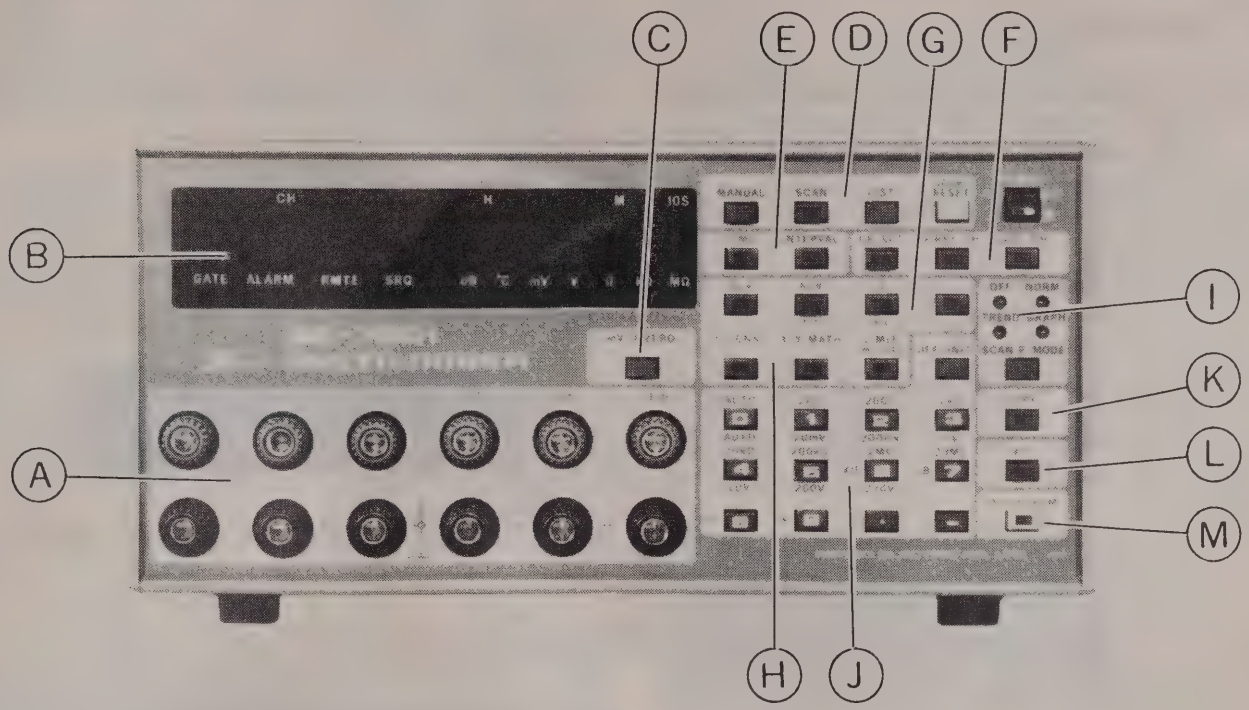
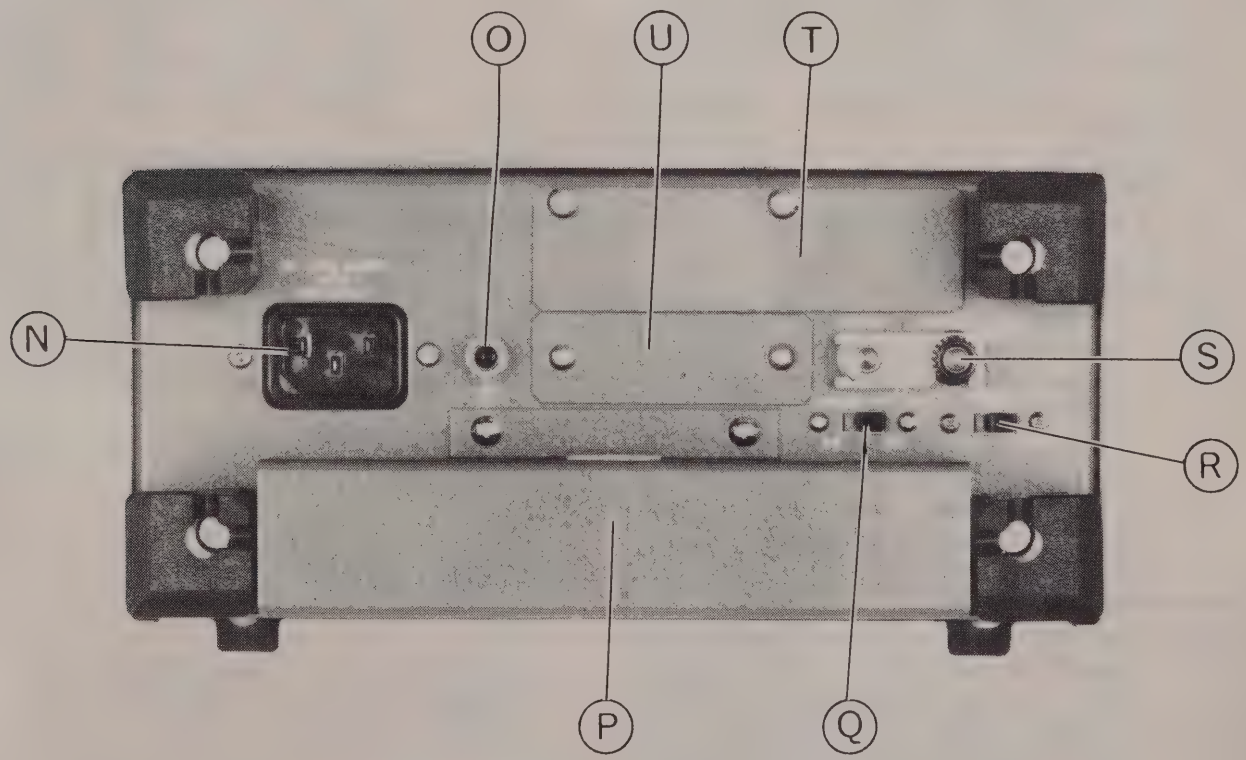


Figure 2-3 Rear Panel



2-3 FUNCTIONS OF OPERATING

2-3-1 Front Panel

As shown in Figure 2-1, the front panel is composed of input terminals Ⓐ, LED indicator part Ⓑ and the keyboard. The beyboard can be classified as follows:

- Operation Instruction Key Ⓓ
- Function-keys
  - Time setting function-key Ⓔ
  - Channel number setting function-key Ⓕ
  - Measurement function-key Ⓖ
  - Calculation and limit setting function-key Ⓗ
  - Plural channel same setting function-key Ⓚ
  - $\bar{x}\sigma$ calculation relating operation key Ⓛ
- Parameter Key Ⓙ
- Other keys
  - SCAN P. MODE Setting key Ⓘ
  - mVΩ ZERO key Ⓒ

As to function-keys and operation instruction key, SCAN key allows the LED in the key to light up during the setting and measuring operations. In the following explanations of the keys, LED lighting-up state is shown by the sign [■].

Ⓐ CH1 to CH6

Input terminals for signals to be measured for measuring DC V, AC V, and resistance. Normally, red lead wire of the measuring cable is connected to the HI side terminal, and black lead wire to the LO side terminal.

Ⓑ LED Indicator

See Figure 2-3.

Ⓒ mVΩ ZERO

A key for performing zero adjustment in DC V or resistance measurement.

Ⓓ Operation Instruction Keys

MANUAL: Performs MANUAL measurement.

SCAN : Starts SCAN measurement.

LIST : Various preset contents for each channels from the FIRST CH to LAST CH are all printed on the printer.

RESET : For use to stop SCAN measurement or LIST operation. When the optional GP-IB interface is installed, it works as the LOCAL key.

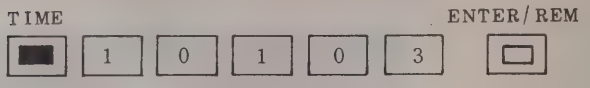
Ⓔ Time Setting Function-key

ITME : For use to set the time of the internal clock, or to confirm the set time. When the key is depressed, the time at that instant is displayed on the data display part for confirmation, and this would not change as the real time.

INTERVAL: For use to set the interval time for SCAN measurement, or to confirm the same. By using the parameter key Ⓙ as a ten-key, time data can be set.

<Example 1>

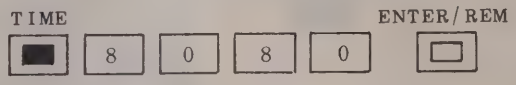
When setting the internal clock to 10 hour, 10 minute 30 second:



By this setting, the data display before depressing the ENTER key will be shown as:

<Example 2>

When setting to 8 hour 8 minute 0 second, set as:



Ⓕ Channel Number Setting Function-key

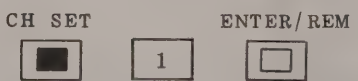
CH SET : Sets the channel to be used for the MONITOR CH as the CH SET. Data relating to the MONITOR measurement, MANUAL measurement, mV ZERO operation, measurement function, range, kind of data processing, value of Y-constant, and limit detection are set by the MONITOR CH.

FIRST CH : Designates the channel of the least number to be used in the SCAN measurement as the FIRST CH.

LAST CH : Designates the channel of the largest number to be used in the SCAN measurement as the LAST CH.

The channel number can be designated, by using the parameter key Ⓙ as a ten-key.

<Example> When designating CH1 as the MONITOR CH (CH SET):



or

Ⓖ Measurement Function

For use to determine the measurement function of the channel that has been set as the MONITOR CH (CH SET).

The measurement function and range can be set

by depressing a key of the aiming measurement function among DCV, ACV, Ω, and TEMP, then setting the range by using the parameter key Ⓙ as the measurement range setting key, and succeedingly by depressing ENTER/REM key Ⓜ.

For example, for setting them to DCV 2V, depress the keys in the order of:

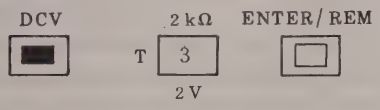
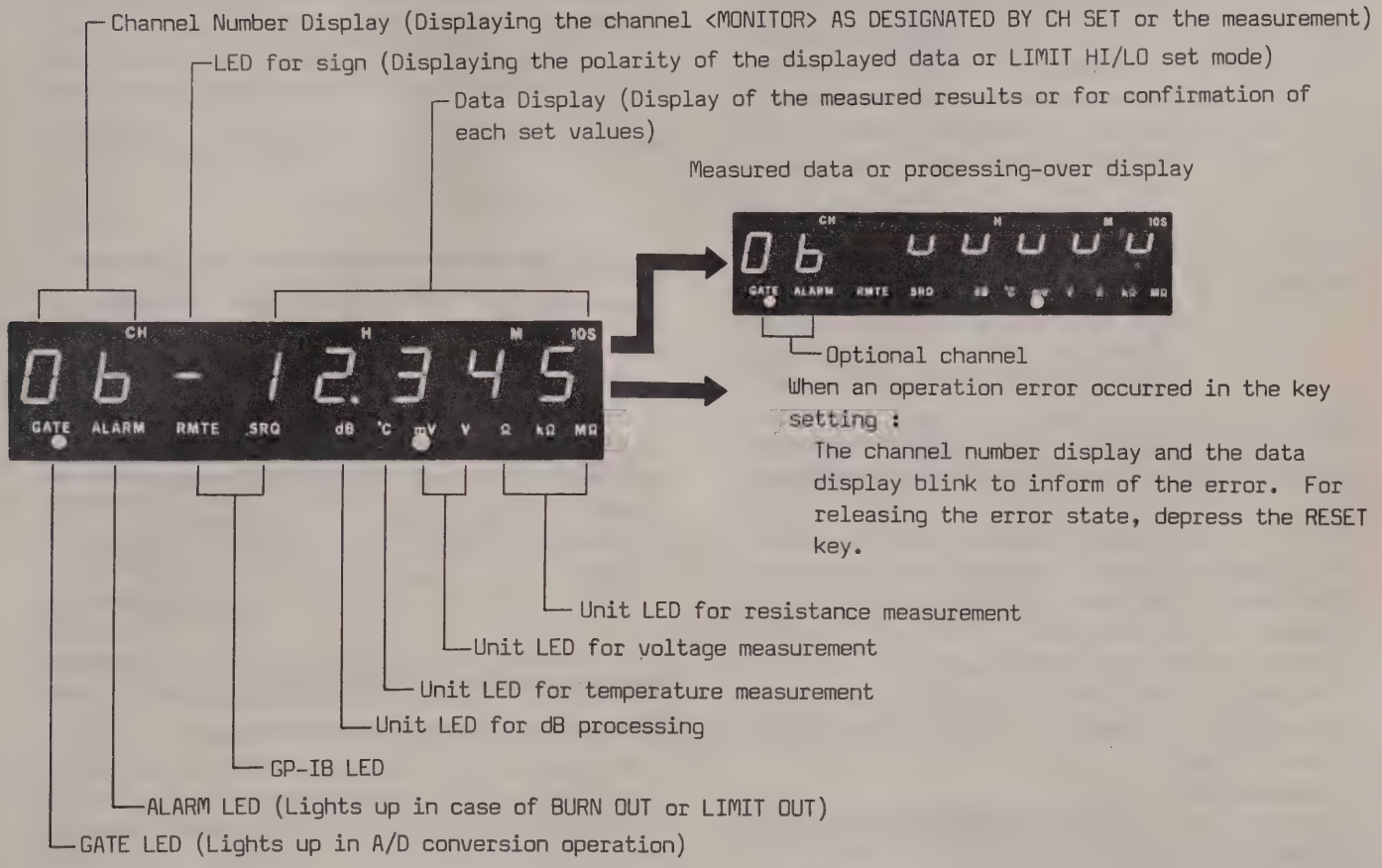


Figure 2-3 LED Display

Channel Number Display Part (Displaying the channel <MONITOR> as designated by CH SET or the measurement)


Channel Number Display (Displaying the channel <MONITOR> AS DESIGNATED BY CH SET or the measurement)
LED for sign (Displaying the polarity of the displayed data or LIMIT HI/LO set mode)
Data Display (Display of the measured results or for confirmation of each set values)
Measured data or processing-over display
Optional channel
When an operation error occurred in the key setting :
The channel number display and the data display blink to inform of the error. For releasing the error state, depress the RESET key.
Unit LED for resistance measurement
Unit LED for voltage measurement
Unit LED for temperature measurement
Unit LED for dB processing
GP-IB LED
ALARM LED (Lights up in case of BURN OUT or LIMIT OUT)
GATE LED (Lights up in A/D conversion operation)

(H) Processing, Limit Setting Function

For use to set the limit detection and processing of the channel designated as the MONITOR CH (CH SET).

LIMIT HI/LO: Pushing this key once sets it to the mode for setting the HI-LIMIT, and pusning the key once more makes it to the mode for setting the LO-LIMIT. Limit value can be set by using the parameter key (J) as the ten-key. Or when there is no need of limit detection, it can be set by depressing the OFF/INIT key and depressing the ENTER/REM (M) key.

X-Y MATH : For use to set the kind of X-Y calculation. After depressing this key, use the parameter key (J) as the processing setting key to select any one of processing OFF, $\bar{x}\sigma$, dB, $\Delta\%$, $*$, $\div$, and Δ , and thereafter depress the ENTER/REM key (M).

Y-CONST : Depressing this key makes it to the mode for setting the constant (Y) for calculation. Succeedingly, enter the data by using the parameter key (J) , and thereafter depress the ENTER/REM key (M) .

(I) SCAN P. MODE Setting Key and LED for Confirmation

tion

For use to determine the printing format of the printer in the SCAN Mode and to confirm the same. Each time pushing the key, the mode changes in the order of:

OFF → NORM → TREND → GRAPH

as well as the display on LED for confirmation above the key.

(J) Parameter Key

This is the parameter key for use to set various parameters.

In the case of setting the time (E) , CH Number (F) , LIMIT value (H) , Y-CONST value (H) , $\bar{x}\sigma$ Maximum sample number (L) , and/or comment (M) , and of designating COPY operation (K) it is used as the ten-key.

In the measurement function setting it is used as the range setting key. In this case, the range set in DC V or AC V is the value indicated below the keys from 0 to 6. However, there is no 20 mV range in AC V. In the case of Ω, it is set to the range indicated above the keys from 0 to 7.

In the case of TEMP, the thermocouple indicated at the left side of the keys from 1 to 5 is selected.

In the processing setting mode, it is used as the key for setting the kind of processing, and the processing indicated at the left side of the keys form 6 to 9, ane . and -keys is selected. Table 2-1 shows the functions of the parameter keys in setting the function-key of each of DC V, AC V, Ω, TEMP, and X-Y MATH.

Table 2-1 Function of Parameter Key

Parameter / Function	0	1	2	3	4	5
DC V, AC V	AUTO	20mV*	200mV	2V	20V	200V
Ω	AUTO	20 Ω	200 Ω	2kΩ	20kΩ	200kΩ
TEMP	—	R	K	T	J	E

* Applied only for DC V.

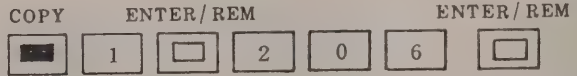
Parameter / Function	6	7	8	9	.	-	OFF/INT
DC V, AC V	270V	—	—	—	—	-	Measurement is not performed.
Ω	2MΩ	20 MΩ	—	—	—	-	
TEMP	—	—	—	—	—	-	
X-Y MATH	$\bar{x}\sigma$	dB	Δ%	*	÷	Δ	Processing is not performed.

(K) Plural Channel Same Setting Function-key

For use to copy the preset content of an arbitrary channel (such as measurement function range, X-Y MATH, LIMIT, AND Y-CONST) to other channels.

<Example>

When copying the preset content of CH1 to the channels 2 to 6, depress the keys in the order of:



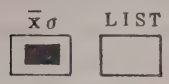
(L) Keies of $\bar{x}\sigma$ data processing

Initialization of $\bar{x}\sigma$ calculation:

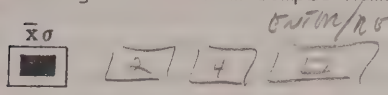
Initialization is executed by depressing the key in the order of:

Printing the result of $\bar{x}\sigma$ calculation at present:

It is executed by depressing the keys in the order of:



Setting the maximum sample number of x̄σ:



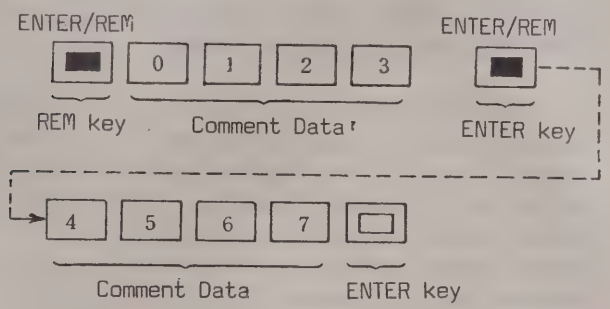
The maximum number of samples can be set by depressing the x̄σ key first, then entering the maximum number of samples by using the parameter key Ⓙ as the ten-key, and thereafter depressing the ENTER/REM key Ⓜ .

Ⓜ ENTER/REM Key

ENTER key: Used as the terminal key when setting is performed by using the parameter key Ⓙ.

REM key : Used for entering the comment (numeral data for comment).

<Example>



2-3-2 Rear Panel

Ⓝ AC LINE INPUT 100V (50/60 Hz))

AC power supply input connector. Connect the supplied power cord.

Ⓞ ⏚

Protective grounding terminal. In order to prevent an unexpected danger, be sure to ground this terminal.

Ⓟ CH7 to CH12

Input terminals (H.L) from channels 7 to 12. Used in measuring dc voltage and temperature.

Ⓠ POWER ON INIT ON/OFF

Used for initializing the set data such as the conditions for measurement and kind of calculation. Normally, it is set to the OFF position, and in this state the set data, backed up by the battery, can be held safe for about 3 months. After passing this period the set data may be unstable due to the lifetime of the battery. In this case, set this switch to ON, and turn on the power switch on the fron panel, and it will be initialized. After setting the data again, set this switch to OFF position.

In the initialized state, CH1 to CH12 are set to DC V, AUTO. And, calculation and limit detection are OFF at each channel. TIME, INTERVAL and REM are reset to zero. Further, SCAN P. MODE is also OFF.

Ⓡ AC V AC/AC + DC

In measuring ac voltage, set to AC when the signals to be measured are only the ac signals, or set to AC + DC when ac signals and dc signals overlap each other.

Ⓢ GUARD ANALOG GND

Normally, GUARD terminal and ANALOG GND terminal are shorted. When noize problem may occur in highly sensitive measurement, release this short and connect the GUARD terminal directly to the ground of the source to be measured.

(Note) ANALOG GND terminal is connected to the LO of the input terminal at the measurement channel in the SCAN mode. It is connected to LO of the MONITOR mode channel, in the MONITOR mode operation.

Ⓣ GP-IB OPTION

When the optional built-in GP-IB is installed, connector for connecting GP-IB cable and address switch are entered in this position.

2-3-3 Recording Paper for Printer

The recording paper is not installed on the printer when the instrument is delivered to you. Accordingly, be sure to install the recording paper before starting to operate this unit. Operating the printer without the recording paper (empty driving), the instrument may cause rapid deterioration of the printing quality.

When the resting paper becomes about a meter, a red mark appears at both ends of the paper. Referring to this mark, replace the paper with a new one.

How to Install the Recording Paper

- As shown in Figure 2-4, insert the supplied recording paper into the enclosing box. There are two spherical projections at the right and left sides in the box. Set these projections to the center of the recording paper.
- Insert the end of the recording paper into the insertion place, (from the lower side of the paper stopper), and roll the paper carrying handle in the arrow direction , and the paper can be carried. Feed the paper until the end reaches the paper cutter portion.

Caution:

. While feeding the paper, do not operate the paper removing button. Otherwise, empty paper feed is caused.

. In installing the recording paper, use care not to mistake the back and the front sides of the paper, referring to Figure 2-4.

How to Remove the Recording Paper

* When removing or changing the recording paper, take out the rest paper from the enclosing box, and pull it in the opposite direction from where in installing the paper while strongly pushing the recording paper removing button towards the front panel.

Figure 2-4 How to Install the Recording Paper for Printer

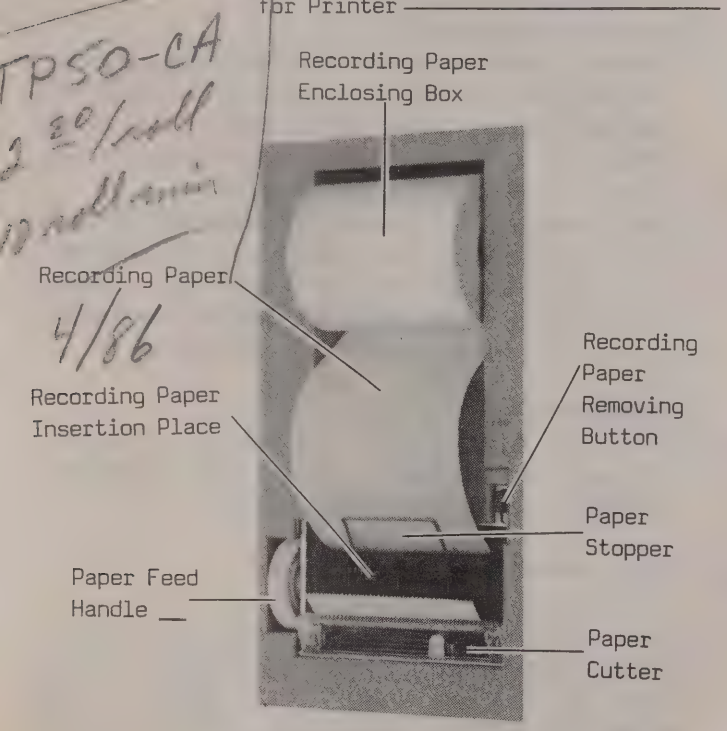
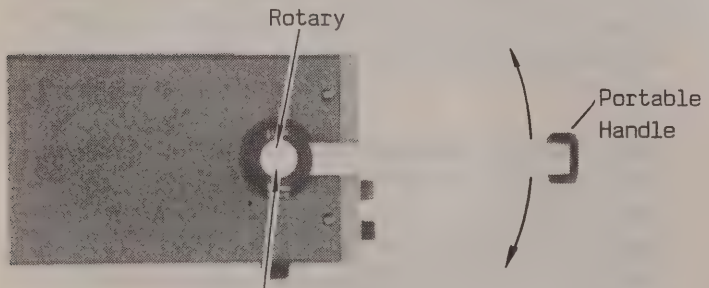


Figure 2-5 How to Use Portable Handle



Set the rotaries at the right and left sides to OPEN, and turn the handle to an arbitrary position, and thereafter be sure to lock them.

Cautions

- Be sure to install the recording paper before operating the printer. Empty operation will cause a rapid deterioration of the printing quality.
- Use the recording paper recommended by IWATSU. When any other paper is used, none of the printing, quality, and lifetime can be guaranteed.
- Printing on the recording paper will be faint by the direct sunshine, non-volatile alcohl and non-volatile ester, or discolored by a volatle organic solvent (e.g. alcohols, esters, and aromatic hydrocarbon). So, use care when preserving the printed recording paper.
- When adhearing the paper, do not use solvent paste.
- Do not keep the paper for a long time under the conditions of high temperature and high humidity. Do not expose the paper to the direct sunshine for a long time.

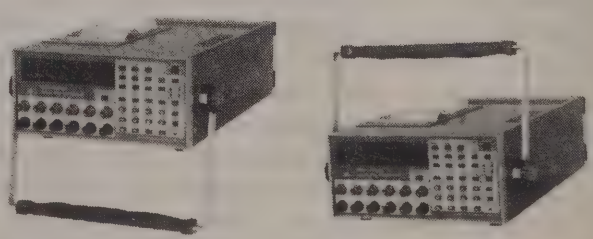
2-3-4 How to Use Carrying Handle

As shown in Figure 2-5, the carrying handle can be rotated freely. Setting the levers at both ends of the rotary of the handle to OPEN (push it in the arrow direction) enables the handle to be turned in the step of about 20°C.
After determining the set position, be sure to set the lever at the rotary to LOCK position.

2-3-5 How to Place SC-7501

The SC-7501 can be set also in a position convenient for measurement by revolving the handle as shown in Figure 2-6 (a). It can be placed also directly on the desk or floor in measurement as shown in Figure 2-6 (b). When this instrument is not used, or is stored, be sure to set the handle in the latter position for the sake of safety. The carrying handle must be set the levers of the rotaries to the LOCK position, after determining the set position.

Figure 2-6 How to Place SC-7501



(a) (b)

2-3-6 Signal Input Terminal on the Rear Panel

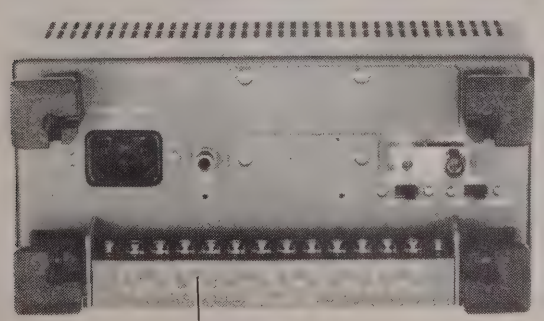
The input terminal on the rear panel are the input terminals of channels 7 to 12. When using these terminals, connect the input signal lead-in wire in the following procedure.

1. Remove 2 pieces of make-up screws fixing the cartridge cover to remove the cover. (Se Figure 2-7)
2. The cartridge is inserted into the connector, so it is removed by pulling it backward.
3. Connect the input signal lead-in wire through the hole on the upper side of the cartridge cover to the terminal plate.
4. Insert the printed plate of the cartridge to the connector.
5. Install the cartridge cover by tightening the pieces of the make-up screws.

Cautions

- Use care not mistake the polarity (H.L terminals) when connecting the input signal lead-in wire to the input terminal.
- Be sure to remove the cartridge from the connector, and pass the lead-in wire through the hole in the case when connecting the input signal lead-in wire to the input terminal.
- When connecting the input signal lead-in wire to the input terminal, connect them securely. Expecially, when measuring the temperature, apply the terminal treatment to the input signal lead-in wire without fail before connecting it to the input terminal.
- In measuring the temperature, twist and securely attach the + foot of the compensating conductor or the thermocouple to the HI terminal of the input terminal and the - foot to LO terminal.
- When measuring the temperature, exposing the input terminal to the wind directly or touching it by your hand directly will cause heat electromotive force, resulting in the measurement error. So care should be paid. If your hand touches it, leave it for several minutes before starting the measurement.

Figure 2-7 Cartridge



2-4 OUTLINE OF FUNCTION AND KEY-OPERATION

Functions of this instrument can be classified largely into two kinds:
one relating to the measurement such as those named as SCAN measurement, MANUAL measurement and MONITOR measurement, and the others relating to the setting of the measurement conditions called EDIT, and LIST, and the output thereof.
SCAN measurement is a mode for scanning and measuring the designated plural channels every fixed time, and MANUAL measurement is a mode for measuring the designated single channel only once when designated by the operator.
After the completion (or stop) of the operations such as SCAN, MANUAL, EDIT, and LIST designated by the operator, this instrument will change to the mode for measuring the designated channel on the designated measuring items in the free run state until next instruction is given by the operator. That is, it works as the usual multimeter. In this case, this measurement mode is especially called MONITOR mode, and the measured channel is called MONITOR CH.
Besides the above, there are corrected value measurement for voltage and resistance measurement (mVΩ ZERO measurement), initialization for statistic processing in SCAN or MANUAL measurement and output of the results (x INIT and x LIST) in the functions relating to the measurement.
SCAN, MANUAL, mVΩ ZERO, and LIST are activated by depressing the corresponding key. EDIT is performed by means of a key representing the item of condition to be set function-key a parameter key for each item, and the ENTER key indicating the completion of input.
However, these key inputs are enabled only in the MONITOR mode. In other words, once the operation mode is started, no key-in except SCAN P. MODE key-in, later explained, is accepted until the operation is normally completed or halfway stopped to return to the MONITOR mode. The operation is stopped by tHe RESET key input.

2-5 VARIOUS SETTING PROCEDURES

Most of various settings in this instrument are performed by depressing the keys in the order of "Function -Key" ⟶ "Parameter Key" ⟶ "ENTER/REM Key".
The function-keys are provided with LEDs on the center of the key for confirming the currently set item. In addition, set value can be confirmed by the numeral display LED during the setting operation.
For example, when Y CONST is set to 12345, depressing the Y CONST key allows the key center LED to light up, displaying the current Y CONST value

and MONITOR CH number on the LED display.
Next, pushing the parameter key [1] makes the LED display as "␣␣␣1" (first four digits remain blank). Further inputting [2], [3], [4], and [5] makes the display as " 1 2 3 4 5 ". Finally pushing ENTER/REM key allows the new Y CONST value to be registered internally, turning out the LED on the center of the Y CONST key, and returning to the MONITOR measurement mode.
If an unallowable parameter key is entered while setting a parameter (for example, Y CONST OFF/INIT, or AC V 20 mV), LED indicator blinks to inform you of this orror. In this case, depress the RESET key to return to the MONITOR mode, or set the parameter once again starting from depressing the function-key to designate the set item.

2-6 MEASURING PROCEDURE AND OPERATING INSTRUCTION

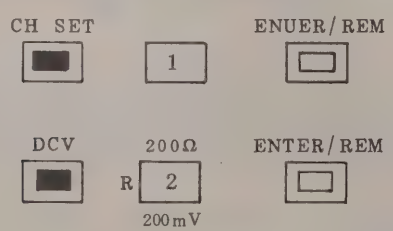
Here explained is the basic operating procedures for measuring the dc and ac voltages, resistance and temperature. For correct measurement, adjust mVΩ ZERO at need.
Also, warm up for about 30 min. for stabilizing the operation.

2-6-1 DC Voltage Measurement

Refer to Figure 2-8.
1. Designate any one of the channel number 1 to 12, and connect the measuring cable to the input terminal corresponding to that channel.
2. Push CH SET key.
3. Using the parameter key as a ten-key, set the channel number.
4. Depress the ENTER/REM key.
5. Depress the DC V key.
6. According to the values to be measured, select a range from AUTO, 20 mV, 200 mV, 2V, 20V, 200V, and 270V, and depress the parameter key corresponding to that range.
7. Depress the ENTER/REM key.

Above operation makes the instrument ready for the measurement of dc voltage.

<Example>
When setting dc voltage 200 mV range at CH1, depress the keys in the order of:



Moreover, adjust the mVΩ ZERO if necessary. For this, operate as follws, after the above step 7.

8. Short-circuit the tip end of the measuring cable.
9. Depress the mVΩ ZERO key.

Only the above steps complete the correction on all ranges of dc voltage.

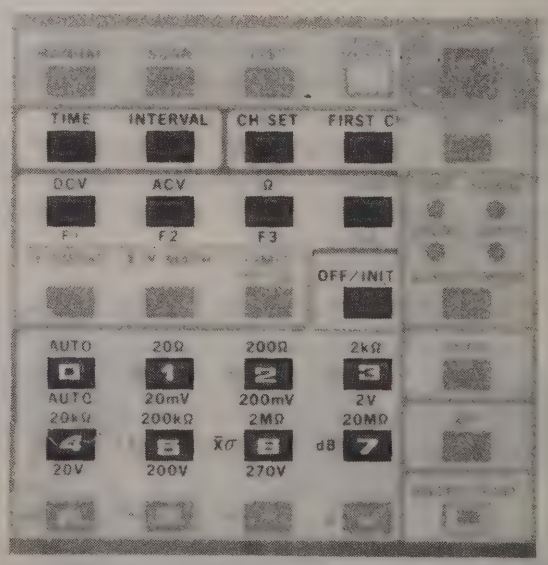
<Cautions>
- mVΩ ZERO adjustment is executed only when setting DC V at the designated channel.
- All channels 1 to 12 can be used for measuring dc voltage.

2-6-2 AC Voltage Measurement

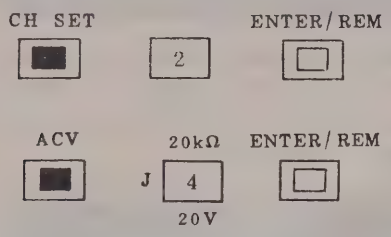
Refer to Figure 2-8.
1. Designate any one of the channel number 1 to 6, and connect the measuring cable to the input terminal of that channel.
2. Depress the CH SET key.
3. Using the parameter key as the ten-key, set the channel number.
4. Depress the ENTER/REM key.
5. Depress AC V key.
6. According to the values to be measured, select a range from AUTO, 200 mV, 2V, 20V, 200V and 270V, and depress the parameter key corresponding to that range.
7. Depress the ENTER/REM key.

Above operation makes the instrument ready for measurement of ac voltage.

Figure 2-8 Measurement Function Range Setting Key



<Example>
When setting ac voltage 20 V range at CH2, push the keys in the order of:



<Cautions>
- Channels 1 to 6 only can be used for measuring ac voltage.
- 20 mV range cannot be used.

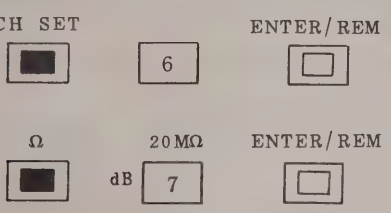
2-6-3 Resistance Measurement

Refer to Figure 2-8.

1. Designate anyone of the channel numbers 1 to 6, and connect the measuring cable to the input terminal of that channel.
2. Depress the CH SET key.
3. Using the parameter key as the ten-key, set the channel number.
4. Depress the ENTER/REM key.
5. Depress the Ω key.
6. According to the values to be measured, select a range from AUTO, 20Ω, 200Ω, 2kΩ, 200kΩ, 2MΩ, and 20MΩ, and depress the parameter key corresponding to that range.
7. Depress the ENTER/REM key.

Above operation makes the instrument ready for the measurement of resistance.

<Example>
When setting 20MΩ range at CH6, push the keys in the order of:



In addition, adjust mVΩ ZERO if necessary. For this, take the following steps after the above step 7.

8. Short-circuit the tip end of the measuring cable.
9. Depress the mVΩ ZERO key.

Only these steps complete correction on all ranges for measurement of resistance automatically.

<Cautions>
- Ω ZERO correction is executed only when setting Ω at the designated channel number.
- CH1 to CH6 can be used for measuring the resistance.

2-6-4 Temperature Measurement

1. Designate anyone of the channel numbers 7 to 12 on the input terminal plate (see Figure 2-7) on the rear panel, and connect the thermocouple to the input terminal of that channel (see the former section "Input Terminal Plate on the Rear Panel").
2. Depress the CH SET key.
3. Using the parameter key as a numeral key, designate the channel number
4. Depress the ENTER/REM key.
5. Depress the TEMP key.
6. According to the type of the thermocouple connected to the input terminal, select a range from R, K, T, J, and E, and depress the parameter key corresponding to that range. (See Table 2-2.)

Table 2-2 Thermocouple for Measuring the Temperature

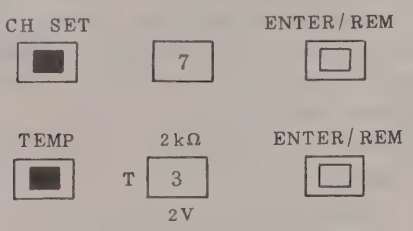
Type of Thermocouple	Temperature Range	Use	Usable Atmosphere
R(Platinum - Platinum Rhodium)	0 to +1600°C	For high temperature (1000°C or more)	Oxidation -Proof
K(CA) (Chromel - alumel)	-200 to +1200°C	For measurement 1000°C or less	Oxidation -Proof
T(CC) (Copper - Constantan)	-200 to +350°C	High precision in a range from -70 to +100°C	Weak-Oxidation Reduction -Proof
E(CRC) (Chromel - Constantan)	-200 to +800°C	Measurement of 1000°C or less	Oxidation -Proof
J(IC) (Iron - Constantan)	-200 to +750°C	For medium temperature (400°C or less)	Oxidation -Proof

7. Depress the ENTER/REM key.

Above operation makes the instrument ready for measurement of the temperature.

<Example>

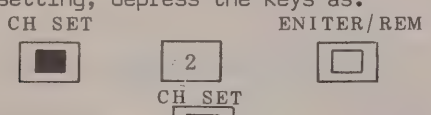
When measuring the temperature by using T thermocouple at the channel 7, depress the keys in the order of:



2-6-5 LED Display in Channel Setting

<Example>

When using the channel 2 (setting the channel 2 to MONITOR CH), provided that the channel 1 has been used previously for measurement or setting, depress the keys as:



At this time, [CH SET], key input allows the key center LED to light up, resulting in the display on the LED display part as:

The last two digits "01" is the MONITOR CH number at that time. Input of [2] key allows the LED display change to:

The ENTER/REM key input makes the channel number 2 registered as the CH SET, resulting in the MONITOR mode at the channel 2.

2-6-6 LED Display in Measurement Function Setting

<Example>

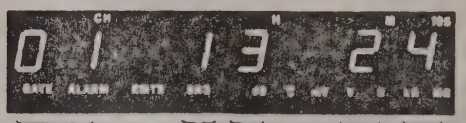
Set AC 20 V range at the channel 1. (Assume that the measurement in DC 2 V range has been made previously.)

1. When AC V key is depressed, LED display will be:

Channel DC V AC V

2 V range

2. Then, depressing the [4] key allows the LED display to change to:



Channel DC V AC V

2 V range 200 V range

3. Now, depressing the ENTER/REM key the AC 20 V range is registered, resulting in the MONITOR mode in AC 20 V range. As shown above, setting can be performed while confirming the previously set measurement function range and the newly set measurement function range. The measurement function and LED numeral correcpond to each other as shown in Table 2-3.

Table 2-3

Measurement Function	DC V F1	AC V F2	Ω F3	TEMP F4
Numeral	1	2	3	4

2-6-7 Calculation

Designation of Type of Calculation

Types of calculation performed on the measured values are: $\bar{x}\sigma$, dB, Δ%, ∗, +, Δ, and OFF/INIT. (See Table 2-4.)

1. Depress the X-Y MATH key. At this time, the key center led lights up.
2. Select the type of aiming calculation by means of the parameter key ($\bar{x}\sigma$ [6], dB [7], Δ% [8], ∗ [9], [÷] [·], Δ [−]), and depress the key. When a mode for performing no calculation is desired, depress the OFF/INIT key as the parameter.
3. Depress the ENTER/REM key. (See Figure 2-9.)

Y CONST Setting

- When performing any calculation except $\bar{x}\sigma$ operation, Y CONST setting is necessary. Set it in the following procedure:

1. Depress the Y-CONST key. Then, the key center LED lights up.

2. Using the parameter key (0 to 9, ., and -) as the ten-key set the value to be used as the Y CONST.
3. Depress the ENTER/REM key.

- When using a measured value at some channel as Y CONST, set it in the following steps:

1. Depress the Y-CONST key. Then, the key center LED lights up.
2. Depress the CH SET key. At this time, LED at the center of the CH SET key would not light up.
3. Using the parameter key as the ten-key, applies the channel number to be used for the Y-CONST.
4. Depress the ENTER/REM key.

Figure 2-9 Setting Keys Relating to Calculation

<Example>

Key input when 1/10 of the measured results is desired.

X-Y MATH ÷ • ENTER/REM

Y-CONST 1 0 ENTER/REM

When you wish to multiply the measured results by the measured results at the channel 1.

X-Y MATH * 9 ENTER/REM

Y-CONST CH SET 1 ENTER/REM

When you wish to prohibit calculation.

X-Y MATH OFF/INIT ENTER/REM

Table 2-4 Display of Content of Calculation and Results thereof

X-Y MATH	Display	Content of Calculation	Result Display		Remarks
			Voltage and Resistance Measurement	Temperature Measurement	
$\bar{x}$. σ	6	Xmin, Xmax $\bar{x}$. σ	Displays the measured value as it is. (Content of the operation is printed on the printer.)		No relation to Y. For details, see the later described section on the statistic operation.
dB	7	$20 \log_{10}(\frac{X}{Y})$ dB	x x x , x x dB		Effective only in case of AC V or DC V measurement. Unit of Y is VOLT. Y ≠ 0 (X/Y) > 0
Δ %	8	$(\frac{X-Y}{Y}) \times 100\%$	x x x , x x (No indicator lamp for the unit. %)		Y ≠ 0
*	9	X x Y	*1	x x x x, x °C	
÷	.	X / Y	Same as *	x x x x, x°C	Y ≠ ϕ
Δ	-	X - Y	Fixed according to the measured range	x x x x, x°C	

*1 -- The decimal point range changes automatically so that the display of the maximum is obtained. Unit depends on the measured value (V or Ω).

Caution

- Remember to designate the aiming channel as the CH SET channel in advance.
- If the setting is made so that measured value of its own channel is used as the Y-CONST in * caculation, the square of the measured value is obtained.
- When a measured value of some channel is designated as the Y constant, for example, when the channel 1 is designated for use as Y-CONST in the calculation performed on the channel 2, the operation is performed immediately after the measurement of the channel 2, however, measurement of the channel 1 is not specifically performed prior to the arithmetic operation. Accordingly, in order to perform the calculation with the newest data, it is necessary to perform the measurement of the channel 1 prior to the measurement of the channel 2. (For example, perform the SCAN measurement, setting the channel 1 as the FIRST CH and the channel 2 or after as the LAST CH.) If the scanning is made with the channel 2 as the FITST CH, the value of Y-CONST would not change. In reverse, when the channel 2 is designated as the Y-CONST for the channel 1, scanning from the channel 1 will result in the calculation with the value of the channel 2 at the previous scanning.
- No operation except dB is performed when the measurement is in the automatic range (AUTO) even if the setting for the calculation has been made.
- In case of Δ% and Δ, unit of Y is considered same as that of the measuring range.

  <Example>

  When the measuring range is 200 KΩ, the set value of Y=100.0 is considered as Y-CONST= 100.0 KΩ.

  When the measured value is 199.00 kΩ and Y=100.0, calculation result of Δ% is 99.00%.

  When the measured value is 150.00 KΩ and Y=100.0, calculation result of Δ is 500.00 kΩ.
- Decimal point position and processor over on the display:

  In case of dB: With no relation to DC V and AC V, xxx.xx dB. (Decimal point is fixed.) When Y=0, or (X/Y)≤0 or |Result| >999.99, it will be the processor over.

  In case of Δ%: With no relation to the item to be measured, xxx.xx%. (Decimal point is fixed.) When Y=0 or |Result| >999.99, it will be the processor over.

  In case of * or ÷ calculation on the voltage or resistance measuremnt:

  <Example>

Measured Value	Y	Display
23.45mV	* 10000	234.5 V
23.45kΩ	÷ 10000	2.345 Ω

  As shown above, combination of the range and the decimal point position is made so as to increase the effective digit number. Accordingly, in case of this instrument:

  Minumum display will be x.xxxxmV, x.xxxxΩ

  Maximum display will be xxxxxV, xxxxxMΩ

  When Y=0, or Result >99999V (M) in - calculation, it will be the processor over.

  In case of Δ calculation on the voltage or resistance measurement:

  Decimal point position range depends on the measuring range.

  <Example>

  When Y=12, and in 20 mV range, 12.345 mV - 12 ⟶ 00.345 mV.

  When the operation result cannot be displayed without carrying down the decimal point position determined by the measuring range, it will be the processor over.

  <Example>

  100.00 kΩ - 1100.0 ⟶ Processor over. (It would not be -1000.0 kΩ or -1.0000 MΩ.)

  In case of temperature:

  With no relation to the item to be measured, xxxx.x°C. (Decimal point is fixed.)

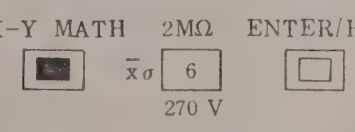
  When the |Result| is larger than 9999.9, it will be the processor over.

Statistic Operation Method

In case of $\bar{x}\sigma$ statistic operation:

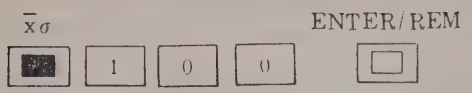
The operating procedure is explained as follows, giving an example of $\bar{x}\sigma$ calculation performed every one hundred times of measurement by which the data of the designated channel are collected. (See Figure 2-10.)

1. After setting the channel number to be calculated as well as measurement function range in advance, set as:



2. In order to initialize the statistic operation memory, set as:

3. In order to set the maximum sample number to 100 times, set as:



After the above operation, in the MANUAL measurment mode or SCAN measurement mode, every 100 times of measurement, calculation results are printed on the printer automatically. Positive or negative sign on the maximum sample number N is used for designating repetition or non-repetition of $\bar{x}$ operation, as explained below.

In case of designating the positive number (N times):

After coming out the results of the designated first to N-th measurements, the statistic calculation memory is automatically initialized state, and continuously transferred to the next measurement activity for next N times, and after coming out the results, it returns to the initialized state again. This is repeated.

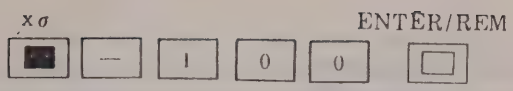
In case of designating the negative number (-N times):

After outputting the results of the designated once to N times measurement, the statistic calculation would not be performed on the (N + 1) times measurement or more. At this time, the internal statistic calculation memory will hold the results of measurements of N times as they are unless initialized.

<Example>

For setting a negative number -100, in the same way as given in the three steps.

Depress the keys in the order of:

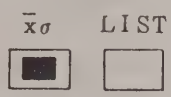


The statistic calculation memory will hold the results as they are.

Meanwhile, the maximum sample number "N" is an integral number in the range from the absolute value 1 to 10000, and is a common setting to the all channels designated for $\bar{x}\sigma$ operation.

When you want to print the calculation results on the printer in the process of the statistic calculation, perform as follows:

Set as



Setting as above allow the printer to print the operation results up to now of all the channels designated for $\bar{x}\sigma$ operation.

<Caution>

Do not convert the measurement function range on the way of the statistic operation.

2-6-8 Limit Detection (Limit Hi/Lo)

This instrument is capable of detecting that the measured result (or the calculation result is an calculation except xσ is designated) is included within some range or not, and of lighting up the ALARM indicator lamp and printing the range-over-mark on the printer according to the result of detection. (See Figure 2-11.)

Following is the explanation of this operation.

Figure 2-10 Key Operation Range in Statistic Operation

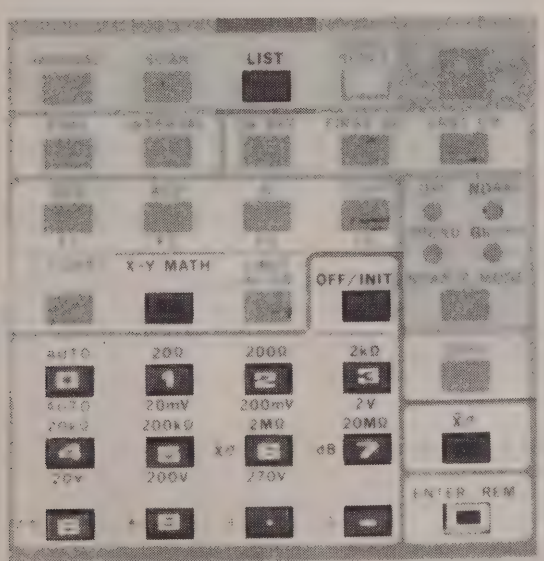
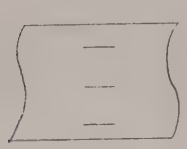


Figure 2-11 Key Operation Range in Limit Detection

Setting the upper limit value for detection

1. Depress the LIMIT HI/LO key once. Then, the key center LED lights up, and - is displayed over the LED for minus polarity.



LED for sign

← LIMIT HI setting display
← Minus polarity display
← LIMIT LO setting display

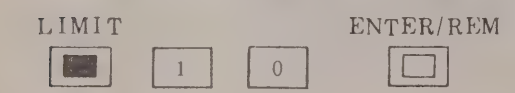
2. Using the parameter key (0 to 9, -, .) as the ten-key, input the upper limit value. (Maximum 5 digits)
   If the upper limit detection is not necessary here, depress the OFF/INIT key instead of applying the upper limit value.
3. Depress the ENTER/REM key.

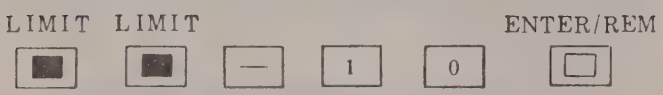
Setting the lower limit value for judgement

1. Depress the LIMIT HI/LO key twice. Then, the key center LED lights up, and - is displayed below the LED for the minus sign.
2. Using the parameter key (0 to 9, -, .) as the ten-key, input the lower limit value. If the lower limit detection is not necessary, depress the OFF/INIT key instead of inputting the lower limit value.
3. Depress the ENTER/REM key.

<Example>

When setting the upper limit value to 10 and the lower limit value to -10:





Cautions

- Remember to designate the channel to be set as the MONITOR CH (CH SET).
- When the measuring range is AUTO, the detection is not performed.
- If the measured result is out of the set range, the mark ▼(indication of lower limit over) or the mark ▲(indication of upper limit over) is printed on the front of the measured value in printing the MANUAL measurement or SCAN measurement (NORM, TREND).
- The unit of the preset limit value is considered the same as the one determined by the measurement function range or calculation. Accordingly, use care in designation of LIMIT value with a possibility of unit change as the result of ∗ or ÷ calculation.

- Measurement function, type of calculation, Y-CONST, and limit detection can be set for each channel independently.

2-7 MONITOR MEASUREMENT

This instrument basically performs the MONITOR measurement except when SCAN measurement is designated by the operator. When LIST, MANUAL, or the like is designated by the operator, it returns to the MONITOR mode after the completion of the designated operation.

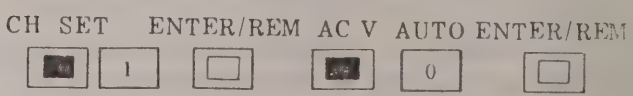
In order to stop the SCAN measurement to return to the MONITOR mode, depress the RESET key.

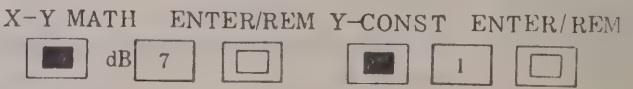
In the MONITOR mode, measurement of the channel (MONITOR CH) designated by CH SET, calculation (except xσ), limit detection (set the limit values in the aforementioned procedure in advance) and LED display of the results are repeatedly performed at the sample rate of 400 m SEC (around 1 second in case of AC V measurement and resistance measurement in 2MΩ range and 20 MΩ range.

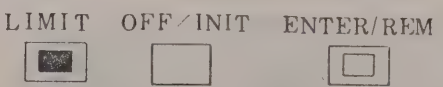
Operation required for the MONITOR measurement is as described above in "Measuring Procedure and Operating Procedure".

<Example>

When the MONITOR measurement of AC V is performed at the channel 1, in AUTO range, with dB calculation (Y=1V), but without limit detection, depress the keys in the order of:







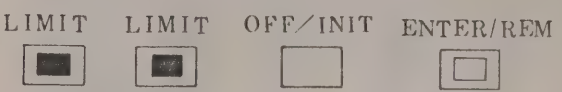
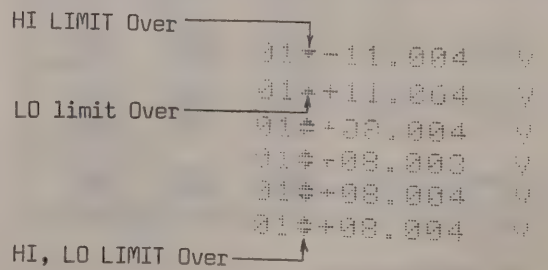


Figure 2-12 Example of Print-out of the Limit Detection in MANUAL Measurement

(Print-out Example)



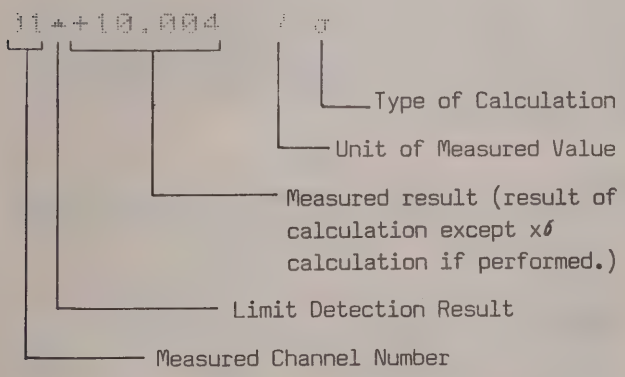
Cautions

- In the MONITOR mode, $x\delta$ operation is not performed. According to the measurement function, LED at the center of the measurement function setting key lights up during measuring operation, and LED at the center of the X-Y MATH key lights up during the calculation. LED of the LIMIT HI/LO key also lights up during the limit detection operation.
- Every key-in is accepted in MONITOR mode.

2-8 MANUAL MEASUREMENT

When the MANUAL key is depressed during the MONITOR measurement operation, the MONITOR measurement is performed once and the result thereof is printed, and thereafter it returns to the MONITOR mode. That is, in the MANUAL mode, measurement, calculation, limit detection, LED display of the results, and printing of the results are performed only once at the MONITOR CH (channel designated by CH SET). At this time, if type of calculation is set to $\bar{x}\delta$ in advance, $\bar{x}\delta$ calculation is also performed.

<Print-out Example>


Type of Calculation
Unit of Measured Value
Measured result (result of calculation except xδ calculation if performed.)
Limit Detection Result
Measured Channel Number

2-9 SCAN MEASUREMENT

SCAN measurement is a mode for performing the scanning, measurement (calculation and limit detection are also performed), and display and printing of the results at the first channel to the last one.
Following is the procedure of SCAN measurement.

2-9-1 Setting of Measurement Function, Range, Calculation, and Limit Detection

Set the measurement function, range, calculation, and limit detection on all channels the same as in the afore-mentioned procedure in the section of "Measuring Procedure and Operating Instruction".

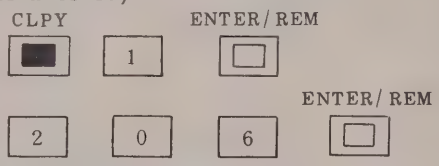
2-9-2 Copy Function (Plural Channels Same Setting)

In case of using the plural channels in the same settings (measurement function, range, calculation, and limit detection), utilize the copy function to make the setting easy. This enables to copy the content of settings for one channel to the plural channels.

<Example>

For using the same settings at the channels 1 to 6.

- Set for the channel 1 as described in the section of "Measuring Procedure and Operating Instruction".
- Depress the keys in the following procedure: (Copy the content for the channel 1 to the channels 2 to 6.)



, here [2] [0] [6] is the same as [0] [2] [0] [6] , showing the copy start and end channels respectively by the leading two digits and the least two digits among the four digits key-in. When the copy start channel is within a range from 1 to 9, setting permitted either in two digits with 0 at the head or in one digit without 0. End channel should be in two digits without fail. (Refer to Figure 2-13.)

2-9-3 Channel Skip Function

If there is any channel unused in the channels for SCAN measurement (between the first channel and the last channel), the mode for measuring without that channel (skip the channel) can be designated. This can be performed by entering OFF/INIT key instead of the parameter key for representing the range in the measurement function and range settings.

<Example> When skipping the channel 3:

CH SET [3] ENTER/REM

DC V OFF/INIT ENTER/REM

This function is permitted in any measurement function of DC V, AC V Ω, and TEMP.

2-9-4 FIRST CH Setting

Set the least number of channel among the channels to be used to the FIRST CH. The procedure therefor is as follows:

1. Depress the FIRST CH key.
2. Using the parameter key as a ten-key, apply the channel number.
3. Depress the ENTER/REM key.

2-9-5 LAST CH Setting

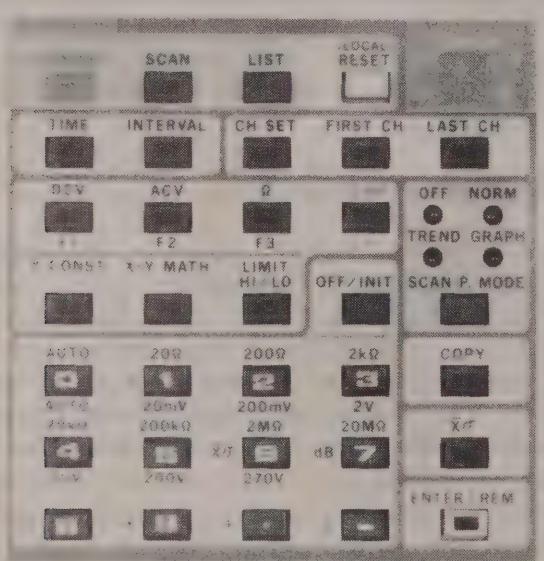
Set the largest number of channel among the channels to be used to the LAST CH. The procedure therefor is as follows:

1. Depress the LAST CH key.
2. Using the parameter key as the ten-key, input the channel number.
3. Depress the ENTER/REM key.

<Example>

In case of designating the first channel and the last channel for the SCAN measurement of the channel 1 to 8, depress the keys in the order of:

Figure 2-13 Key-Operation Range in SCAN Measurement



FIRST CH [1] ENTER/REM

LAST CH [8] ENTER/REM

2-9-6 INTERVAL Setting

Time intervals can be set for performing the scanning, measurement and printing at the designated channel at a fixed interval in the SCAN measruement mode. Following is the procedure of this setting.

1. Depress the INTERVAL key.
2. Set a fixed time interval for repeating the scanning, measurement, and printing by means of the parameter key.
3. Depress the ENTER/REM key.

<Example>

In case of setting the interval to 1 hour 25 minute 30 second, depress the keys in the order of:

INTERVAL [1] [2] [5] [3] ENTER/REM

2-9-7 TIME Setting

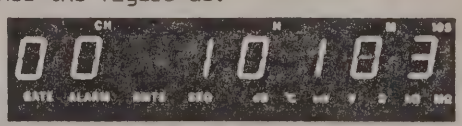
TIME is a key for setting the real time of the clock. If the setting is made once after the power is turned on, the internal clock works thereafter automatically.

<Example 1>

In case of setting the time of the internal clock to 10 hour 10 minute 30 second:

TIME [1] [0] [1] [0] [3] ENTER/REM

The above setting allows the numeral LED display to show the figure as:



before depressing the ENTER/REM key.

<Example 2>

When setting the clock to 8 hour 8 minute 0 second:

TIME [8] [0] [8] [0] ENTER/REM

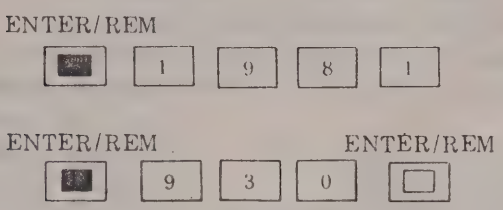
2-9-8 Comment (Numeral for Comment) Data Setting

Comment such as the data number and the date can

be printed.

<Example>

In case of making a comment as "Dated on Sept. 30th, 1981", depress the key in the order of:



2-10-9 Printing Printer Mode Setting

Operation of SCAN P. MODE

This is used for setting the printing format of the results in the SCAN measurement.

Every time pressing the SCAN P. MODE key, switch-over is performed in the order of OFF ⟶ NORM ⟶ TREND ⟶ GRAPH.

OFF : In the case of SCAN mode, the printer would not be operated.

NORM : Results of measurement based on the preset conditions are printed in the all digit parallel printing. (See Figure 2-14 (a))

TREND: Results of measurement based on the preset conditions are printed in the all digit seried printing. (See Figure 2-14 (b))

GRAPH: Results of measurement based on the preset conditions are printed in the graphic form. Format varies depending on whether the channel number to be scanned is only one or more.

This is used to see:

change of designated channels by the passage of time. (See Figure 2-14 (c))

and:

difference between the channels. (See Figure 2-14 (d))

Height of the graph is indicated as

$$\frac{X - L}{H - L} \times 100\%,$$

provided that the measured value (or the calculation value) is X, and LIMIT HI/LO values are H and L respectively.

However, in case of LIMIT HI/LO is "OFF", following values are selected as H and L.

In case of [MATH] - OFF:
Decided by the measurement function range.
± (Full scale value)

In case of [MATH] - ON:
Decided by the type of calculation or the like.
± (Full scale value)

<Caution>

In the calculation of the length of the bar

Figure 2-14 (a) Printing in NORM mode

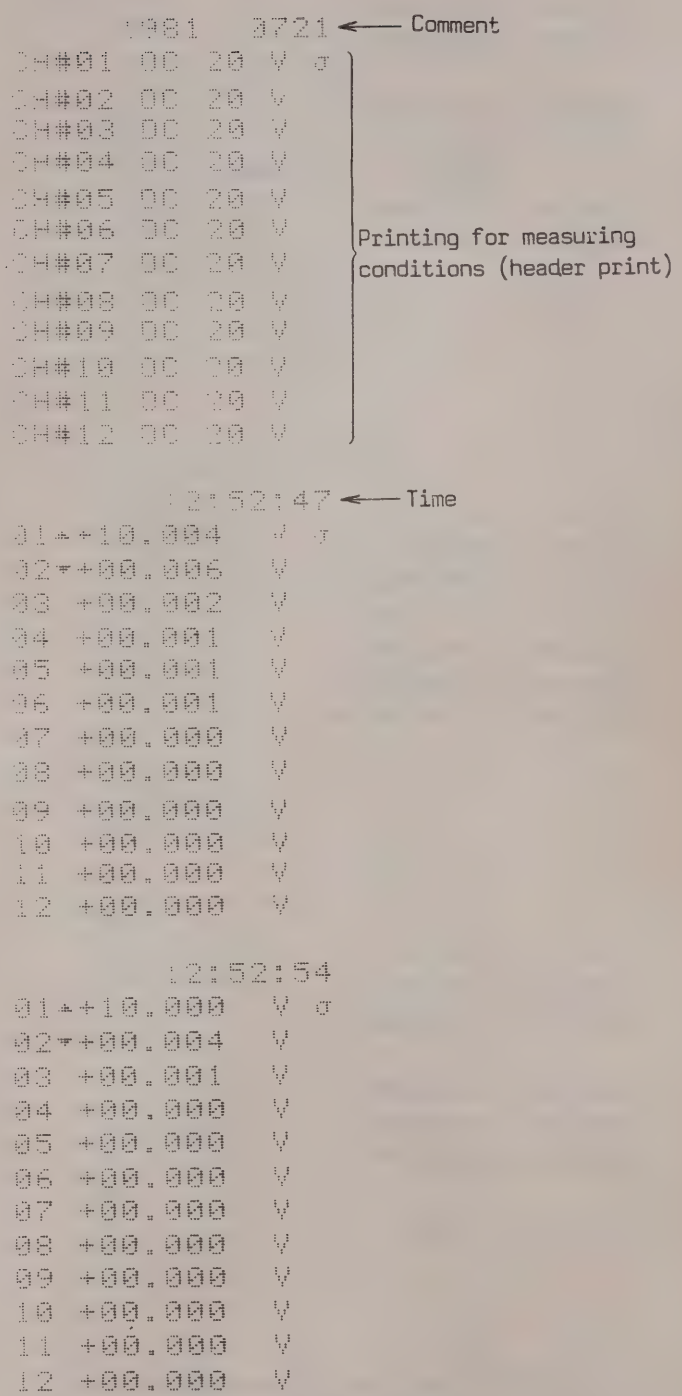


Figure 2-14 (b) Printing in TREND Mode

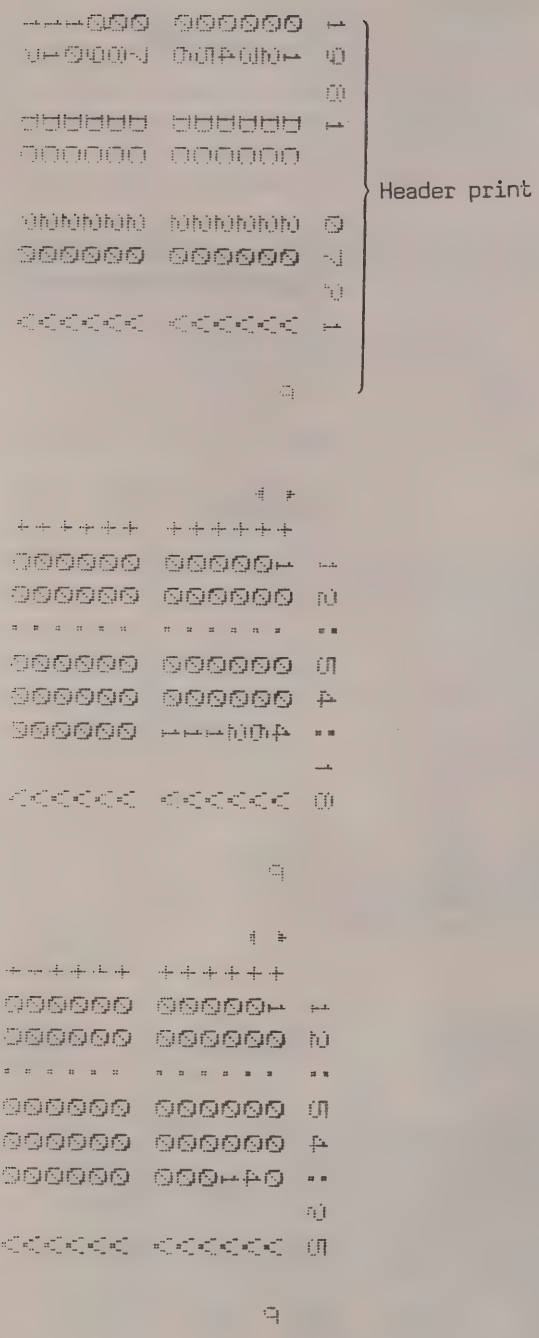
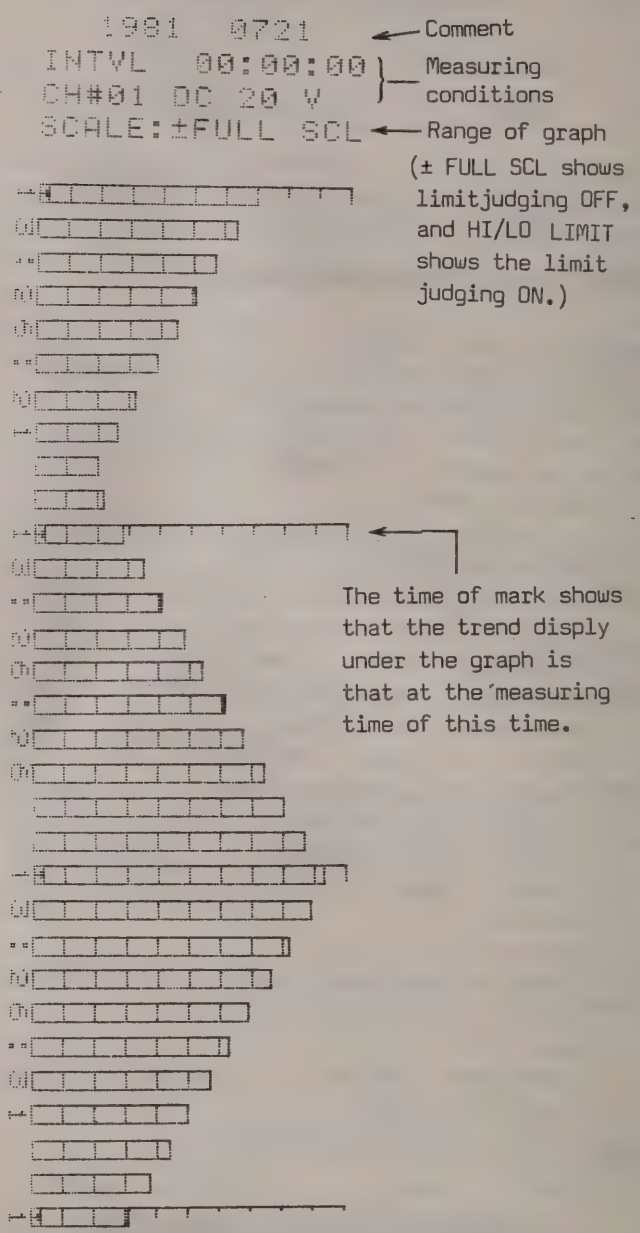


Figure 2-14 (c) Printing in Single Channel Graph Mode


1981 0721
Comment
INTVL 00:00:00
CH#01 DC 20 V
Measuring conditions
SCALE:±FULL SCL
Range of graph
(± FULL SCL shows limitjudging OFF, and HI/LO LIMIT shows the limit judging ON.)
The time of mark shows that the trend disply under the graph is that at the measuring time of this time.

in the graph, decimal point position of each data of X, H, and L, and unit of the same are decided by the measurement function, range and calculation, and considered as fixed. Accordingly, be careful that some graphic print-out of the channels with the designation of Ω or ♦ calculation (this may cause change in the decimal point position and unit of X) may be meaningless.

2- 9 -10 Starting SCAN

Depressing the SCAN key, starts the SCAN operation. While SCAN measurement is performed, LED at the center of SCAN key lights up, and any key-in except the afore-mentioned SCAN P. MODE key and RESET key (this stops the SCAN measurement to return to the MONITOR measurement) is neglected.

2-10 LIST PRINTING

All contents of the various setting are printed on the printer by each channel from the first to the last channels.
Depressing the LIST key, start the LIST printing. An example of LIST print-out is shown in Figure 2-15 (a) and (b).

Cautions

- In key-setting, FIRST CH, LAST CH, INTERVAL, TIME, Comment Data, and printing mode may be set in any order.
- If comment is unnecessary (numeral for comment), setting thereof is unnecessary.
- Set the copy function and the channel skip funciton at need.
- Any operation should be started from the MONITOR mode. It is not in the MONITOR mode, depress the RESET key to make it the MONITOR mode before starting the operation.
- TIME and INTERVAL can be set upto 23 H 59 M 59 S in the step of 10 sec.

Figure 2-14 (d) Printing in Plural Channel GRAPH Mode

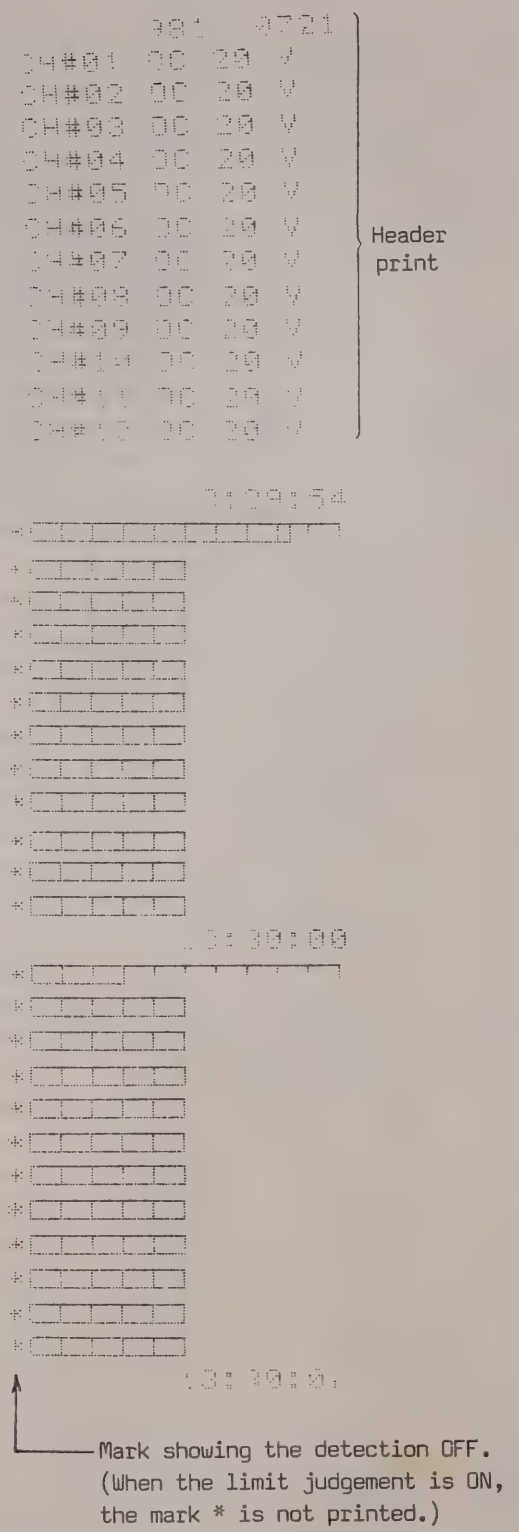


Figure 2-15 (a) Example of List Print-out

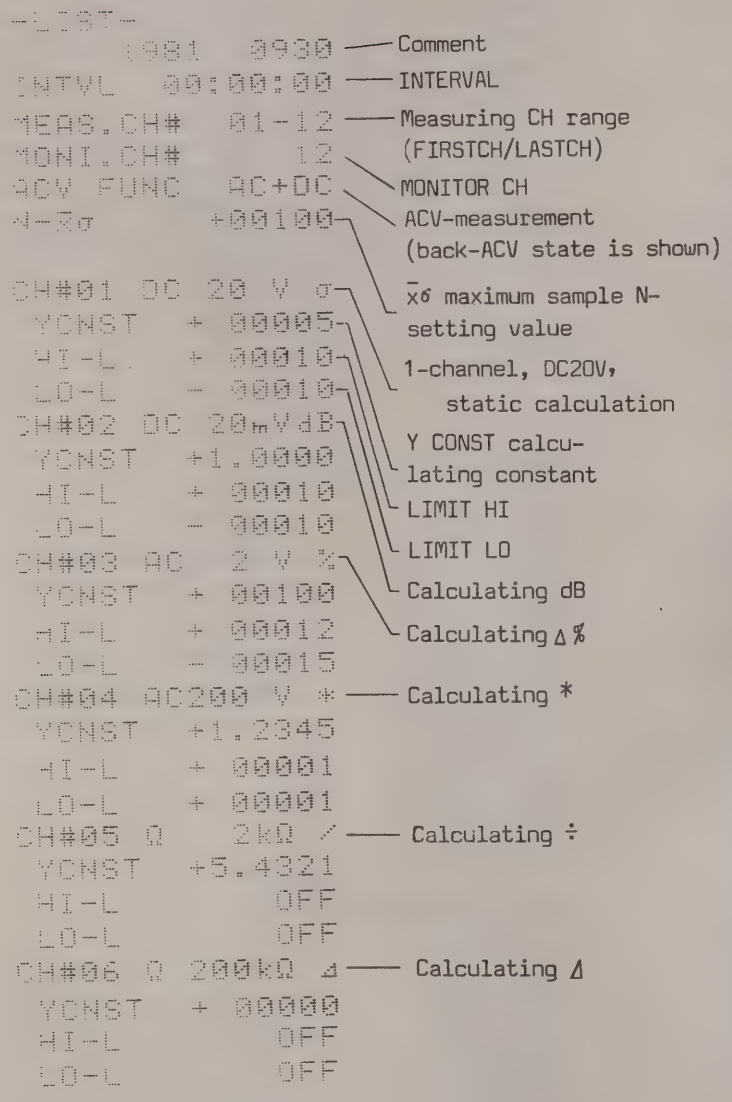


Figure 2-15 (b) Example of List Print-out
(Continued from Figure 2-15 (a).)

```
CH#07 T R
 YCNST   + 00000
 HI-L        OFF
 LO-L        OFF
CH#08 T K/CA
 YCNST   + 00000
 HI-L        OFF
 LO-L        OFF
CH#09 T T/CC
 YCNST   + 00000
 HI-L        OFF
 LO-L        OFF
CH#10 T J/IC
 YCNST   + 00000
 HI-L        OFF
 LO-L        OFF
CH#11 T E/CRC
 YCNST   + 00000
 HI-L        OFF
 LO-L        OFF
CH#12 OFF
 YCNST   + 00000
 HI-L        OFF
 LO-L        OFF
```

Section 3 APPLIED MEASUREMENT

Various measurements can be performed by using this instrument. Some of the applied measurements (temperature inside the equipment, dB calculation, check of parts by statistic processing, gain calculation of an amplifier, and calculation of dc power) are explained in this section.

3-1 INNER TEMPERATURE OF THE EQUIPMENT EQUIPMENT

In case of measuring the rise of the inner temperature of the equipment with the passage of time, measure the raised temperature by calculation as based on the room temperature and print the results in the trend mode.

1. Measure the room temperature at CH7, and measure the temperature inside the object equipment at CHs 8 to 12.
2. Use T (CC) for the thermocouple.
4. Set the keys as follows:

INTERVAL [■] [1] [0] ENTER/REM [□] — Set the measuring intervals to 1 minute.

FIRST CH [■] [7] ENTER/REM [□]

LAST CH [■] [1] [2] ENTER/REM [□] — Use CHs 7 to 12 for measurement.

CH SET [■] [8] ENTER/REM [□] — Set CH 8.

TEMP [■] T [3] ENTER/REM [□] — Set CH 8 to the temperature T (CC).

X-Y MATH [■] Δ [—] ENTER/REM [□] — Set CH 8 to calculation

Y CONST CH SET [■] [□] [7] ENTER/REM [□] — Set the calculation constant at CH 7.

COPY [■] [8] ENTER/REM [□] [9] [1] [2] ENTER/REM [□]

Copy the set conditions for CH8 to from CH9 to 12 by the above operation.

CH SET [■] [7] ENTER/REM [□]

Set CH 7 by the above operation.

Figure 3-1 LIST Print-out of the Conditions for Temperature Measurement

```
-LIST-
      991   0930
INTVL   00:01:00
MEAS.CH#   07-12
MONI.CH#      07
ACV FUNC   AC+DC
A-ZRO      +00100

CH#07 T T/CC
 YCNST   + 00000
 HI-L        OFF
 LO-L        OFF
CH#08 T T/CC  ⊿
 YCNST     CH#07
 HI-L        OFF
 LO-L        OFF
CH#09 T T/CC  ⊿
 YCNST     CH#07
 HI-L        OFF
 LO-L        OFF
CH#10 T T/CC  ⊿
 YCNST     CH#07
 HI-L        OFF
 LO-L        OFF
CH#11 T T/CC  ⊿
 YCNST     CH#07
 HI-L        OFF
 LO-L        OFF
CH#12 T T/CC  ⊿
 YCNST     CH#07
 HI-L        OFF
 LO-L        OFF
```

TEMP ■ T 3 ENTER/REM □ Set CH 7 to the temperature T (CC).

X-Y MATH ■ OFF/INIT □ ENTER/REM □ Set the calculations OFF at CH 7.

1. After depressing the keys in the above-mentioned order, set the SCAN P. MODE to TREND.
2. If it is desired to confirm the set conditions, depress the LIST key. (See Figure 3-1.)
3. Depressing the SCAN key, starts the measurement.

3-2 dBm CALCULATION

Set the instrument to AC couple at AC V Auto range. (Rear panel switch)
Perform dB m conversion on the voltages at CH 1 and CH 2, provided that Y=0.7746 V =0 dB m : 600 Ω impedance) in the operation of 20 $\log_{10} \frac{Y}{X}$.

See the measuring intervals to 1 minute.

1. Set the keys as follows:

INTERVAL ■ 1 0 ENTER/REM □ Set the intervals to 1 min.

FIRST CH ■ 1 ENTER/REM □ Measure at CH1 and CH2.

LAST CH ■ 2 ENTER/REM □

CH SET ■ 1 ENTER/REM □ Set CH 1.

AC V ■ AUTO 0 ENTER/REM □ Set Auto range at AC V.

X-Y MATH ■ dB 5 ENTER/REM □ Set the calculation to dB.

Y CONST ■ • 7 7 4 6 ENTER/REM □ Set the Y value to 0.7746.

COPY ■ ENTER/REM 1 □ 2 0 2 ENTER/REM □ Copy the setting for CH1 to CH2.

2. After setting each parameter in the above procedure, set the SCAN P. MODE to NORM.
3. In case of it is desired to confirm the set conditions, depress the LIST key. (See Figure 3-2)
4. In case of it is desired to insert the comment data (numeral for comment), set as follows:

<Example>

In case of setting as September 15, 1981:

ENTER/REM ■ 1 9 8 1 ENTER/REM ■ 9 1 5 ENTER/REM □

5. Depressing the SCAN key actuates the measurement. (See Figure 3-3)

Figure 3-2 Print-out of Calculation Conditions

```
      1981  0915
TIME  08:01:00
MEAS.CH#   01-02
MONI.CH#      01
ACV FUNC   AC
M-Xσ      +10000

CH#01 AC AUTOdB
 YCNST  +0.7746
 HI-L       OFF
 LO-L       OFF
CH#02 AC AUTOdB
 YCNST  +0.7746
 HI-L       OFF
 LO-L       OFF
```

Figure 3-3 Print-out of Measured Data

```
      1981  0915
CH#01 AC AUTOdB
CH#02 AC AUTOdB

      14:49:49
01 +022.91 dB
02 -031.52 dB

      14:50:50
01 +022.91 dB
02 -031.54 dB
```

3-3 CHECK OF PARTS BY STATISTIC

Measure the maximum, minimum, average values and standard variation of 10 units of sample resistors by using CH1, and print the results in MANUAL mode.

1. Set the keys as follows:

CH SET ■ | 1 | ENTER/REM □ — Set CH 1.

Ω ■ | 20 kΩ 4 | ENTER/REM □ — Set to 20 kΩ range.

X-Y MATH ■ | 2MΩ $\bar{x}\sigma$ 6 | ENTER-REM □ — Set the calculation type to $\bar{x}\sigma$.

$\bar{x}\sigma$ ■ | 1 | 0 | ENTER/REM □ — Set the number of measurement to 10 times.

$\bar{x}\sigma$ ■ | OFF/ININT □ | ENTER/REM □ — Initialization of statistic processing.

2. Connect the resistor to the input terminal of CH 1.
3. Depress the MANUAL key. Every time depressing the MANUAL key, printing on the printer is performed once.
4. Changing the resistors in sequence, perform the measurement by depressing the MANUAL key 10 times, and the results of the statistic processing are automatically printed.
5. Figure 3-4 shows the print-out of the LIST and the results of measurement on 1/4 W, 16 kΩ carbon film resistor.

Figure 3-4 Print-out of Conditions for Measurement Resistor

```
-LIST-
      1981  0529
INTVL  00:01:00
MEAS.CH#  01-01
MON.CH#      01
ACV FUNC  AC+DC
N-σx̄σ     +00010

CH#01 R   20kΩ σ
 YCNST  +0.7746
 HI-L       OFF
 LO-L       OFF

01  +15.857 kΩ σ
01  +16.009 kΩ σ
01  +15.974 kΩ σ
01  +15.822 kΩ σ
01  +15.960 kΩ σ
01  +16.179 kΩ σ
01  +15.779 kΩ σ
01  +15.732 kΩ σ
01  +15.868 kΩ σ
01  +15.767 kΩ σ

CH#01
N     00010/00010
MIN   +15.732 kΩ
MAX   +16.179 kΩ
X̄     +15.8947kΩ
σ     +00.1296kΩ
```

LIST

Measured results

Number of measurement — N

Minumum Value — MIN

Maximum Value — MAX

Average Value — $\bar{x}$

Standard Variation — σ

3-4 GAIN CALCULATION OF AMPLIFIER

Following is an explanation of how to measure the gain of the amplifier shown in Figure 3-5.

* Perform measurement on the gain = 20 log $\frac{V\ out}{V\ in}$ dB.

1. Set the keys as follow:

INTERVAL [1] [0] ENTER/REM — Set the intervals to 1 minute.

FIRST CH [1] ENTER/REM
LAST CH [3] ENTER/REM — Set from CH 1 to CH 3.

CH SET [1] ENTER/REM — Set CH 1.

AC V [3] (2V) ENTER/REM — Set AC 2V range.

X-Y MATH OFF/INIT ENTER/REM — Calculation is not to be performed at CH 1.

COPY [1] ENTER/REM
[2] [0] [3] ENTER/REM — Copy the setting for CH 1 to CH 2 and CH 3.

CH SET [3] ENTER/REM — Set CH 3.

X-Y MATH dB [7] ENTER/REM — Set the type of calculation for CH 3 to dB.

Y CONST CH SET [1] ENTER/REM — Set the constant for calculation for CH 3 to the data at CH 1.

2. Set the SCAN P. MODE to NORM.
3. In case of it is desired to confirm the set conditions, depress the LIST key. (See figure 3-6)
4. After performing each setting in the above procedure, depressing the SCAN key, starts the measurement.

Figure 3-5 Amplifier

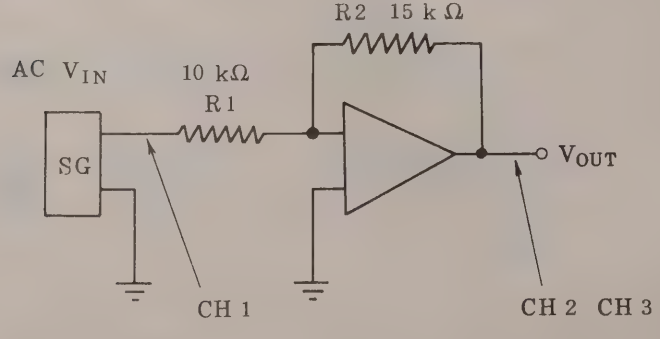


Figure 3-6 Print-out of Conditions for Gain Measurement of the Amplifier

```
-LIST-
        1991  0930
INTVL   00:01:00
MEAS.CH#   01-03
MONI.CH#      03
ACV FUNC    AC
ﾍｰｽｳ        +00010

CH#01 AC   2 V
 YCNST   + 00010
 HI-L        OFF
 LO-L        OFF
CH#02 AC   2 V
 YCNST   + 00010
 HI-L        OFF
 LO-L        OFF
CH#03 AC   2 VdB
 YCNST     CH#01
 HI-L        OFF
 LO-L        OFF
```

LIST

```
        1991  0930
CH#01 AC   2 V
CH#02 AC   2 V
CH#03 AC   2 VdB

                09:06:13
01  +1.0006   V
02  +1.4999   V
03  +003.52  dB

                09:07:13
01  +1.0003   V
02  +1.4999   V
03  +003.52  dB

                09:08:13
01  +1.0004   V
02  +1.4998   V
03  +003.52  dB
```

Input Voltage — 01 +1.0006 V
Output Voltage — 02 +1.4999 V
Gain — 03 +003.52 dB

Measured data

3-5 CALCULATION OF POWER

Following is an explanation of how to measure the power consumption of R in the circuit diagram shown in Figure 3-7 every one minute. (For example, use DC 2V range.)

1. Set the keys as follows:

INTERVAL ■ 1 0 ENTER/REM □ — Set the intervals to 1 minute.

FIRST CH ■ 1 ENTER/REM □
LAST CH ■ 2 ENTER/REM □ — Set CH1 and CH2.

CH SET ■ 1 ENTER/REM □ — Set CH1.

DC V ■ 3 (2V) ENTER/REM □ — Set CH1 to DC 2V range.

X-Y MATH ■ ÷ • ENTER/REM □
Y CONST ■ • 5 ENTER/REM □ — Result of $\frac{CH1}{0.5\Omega}$ (Calculation for evaluating the current)

CH SET ■ 2 ENTER/REM □ — Set CH2.

DC V ■ 3 (2V) ENTER/REM □ — Set DC 2V range.

X-Y MATH ■ * 9 ENTER/REM □
Y CONST ■ CH SET □ 1 ENTER/REM □ — CH1 x CH2 Power (Current x Voltage)

2. Set the SCAN P. MODE to NORM.
3. Depress the LIST key to confirm the set conditions, if you wish. (See Figure 3-8)
4. After performing each setting in the above procedure, depress the SCAN key, and the measurement starts.

Figure 3-7 Circuit for Measuring the Power

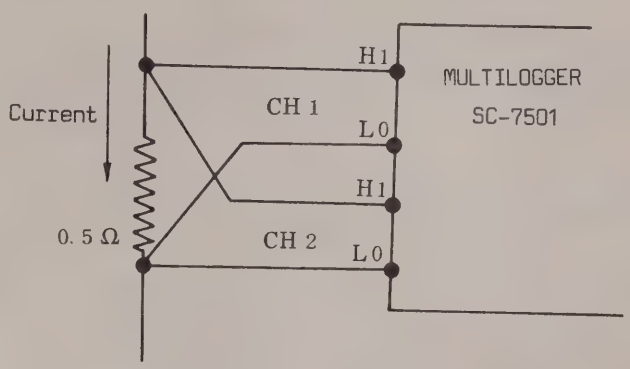
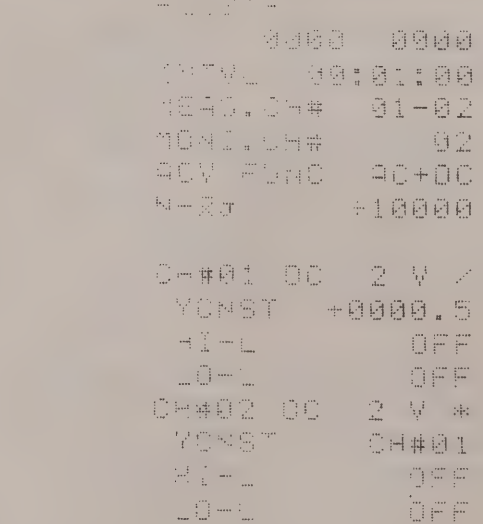


Figure 3-8 Print-out of Conditions for Measurement of Power



Section 4 PRINCIPLES OF OPERATION

4-1 CIRCUIT COMPOSITION

This instrument can be classified largely into the analog division and the digital division as shown in Figure 4-1.
The analog division is composed of the multiplexer of 12 channels, the signal conditioner for converting the input signals of DC and AC voltages, resistance and temperature to the suitable DC voltage, the A/D converter of 41/2 digits, the burn-out detection circuit for detecting the thermocouple breaking during thermal measurement, the analog control logic for controlling the multiplexer and the signal conditioner, and the A/D logic for controlling the A/D converter.
The digital division is composed of the read-only-memory (ROM) 12 KB, the random-access-memory (CMOS RAM) 2KB backed up by the battery, the analog control interface for controlling the analog division, A/D data interface for taking in the measured data, printer interface, thermal printer, and keyboard A/D LED displays and the interface thereof, centering the CPU 8085A.
In order to insulate the analog part and the digital part electrically, data transfer between them is performed through the photo-coupler and the isolate transforrer.

4-2 OPERATION OF ENTIRE INSTRUMENT

Operation of this instrument can be largely classified into two categories: three kinds of modes relating to the measurement such as SCAN measurement, MANUAL measurement, and MONITOR measurement; and operations relating to the setting of measurement conditions by key input, and the output thereof respectively called EDIT and LIST.
Scan mode is a mode for performing the scanning, measurement and printing on the designated channel at intervals of fixed time.
Manual mode is a mode for performing the measurement and printing only once when the manual key is depressed.
Monitor mode is a mode for always performing the measurement on the specified channels and the specified measuring items when waiting for passage of interval time in the scan mode, or when the scan mode is not specified.
The measuring frequency in this mode is once about 400 m SEC in the case of DC voltage measurement.
Besides the above measuring operations, there are the measurement of corrected value (mVΩ ZERO MEAS) for input zero adjustment in low level DC voltage (20 mV - 2V range) and resistance (20Ω - 2KΩ range) measurements, and initialization for statistic processing in SCAN, and MANUAL measurements, and output of the results thereof ($\bar{x}\sigma$INIT and $\bar{x}\sigma$LIST).

4-3 OPERATION IN SCAN MODE

Operation in the Scan mode is as follows:

1. When the SCAN key is depressed, the time at that time is stored in the internal memory, and the conditions for measurement are printed.
2. uCPU transmits the conditions for measurement on the first channel to the analog part through the analog control interface.
3. Measurement is performed under the designated conditions, and after A/D conversion, A/D converted data is transmitted to uCPU, correction operation is performed on the A/D conversion data, and the designated operation and limit judgement are performed, and thereafter, the results thereof are indicated on LED display.
4. The results of the above 3 items are stored in the internal memory.
5. Conditions for the measurement on the next channel are transmitted to the analog part.
6. Hereafter, operations in the above items 3 and 4 are repeatedly performed.
7. When the measurement on the last channel is completed, time and the data of first to last channels stored in the memory are printed on the printer in the designated format.
8. Until another scan measuring time comes after the passage of interval time, measurement start signal in the Monitor mode is output from uCPU so as to perform the operations given in the above item 3.
9. Until the next scan measuring interval has passed, operation in the above item 8 is repeated.
10. When the Scan start signal is output (scan interval has passed), operations are repeated from the above item 2.

Figure 4-1 : Circuit Diagram

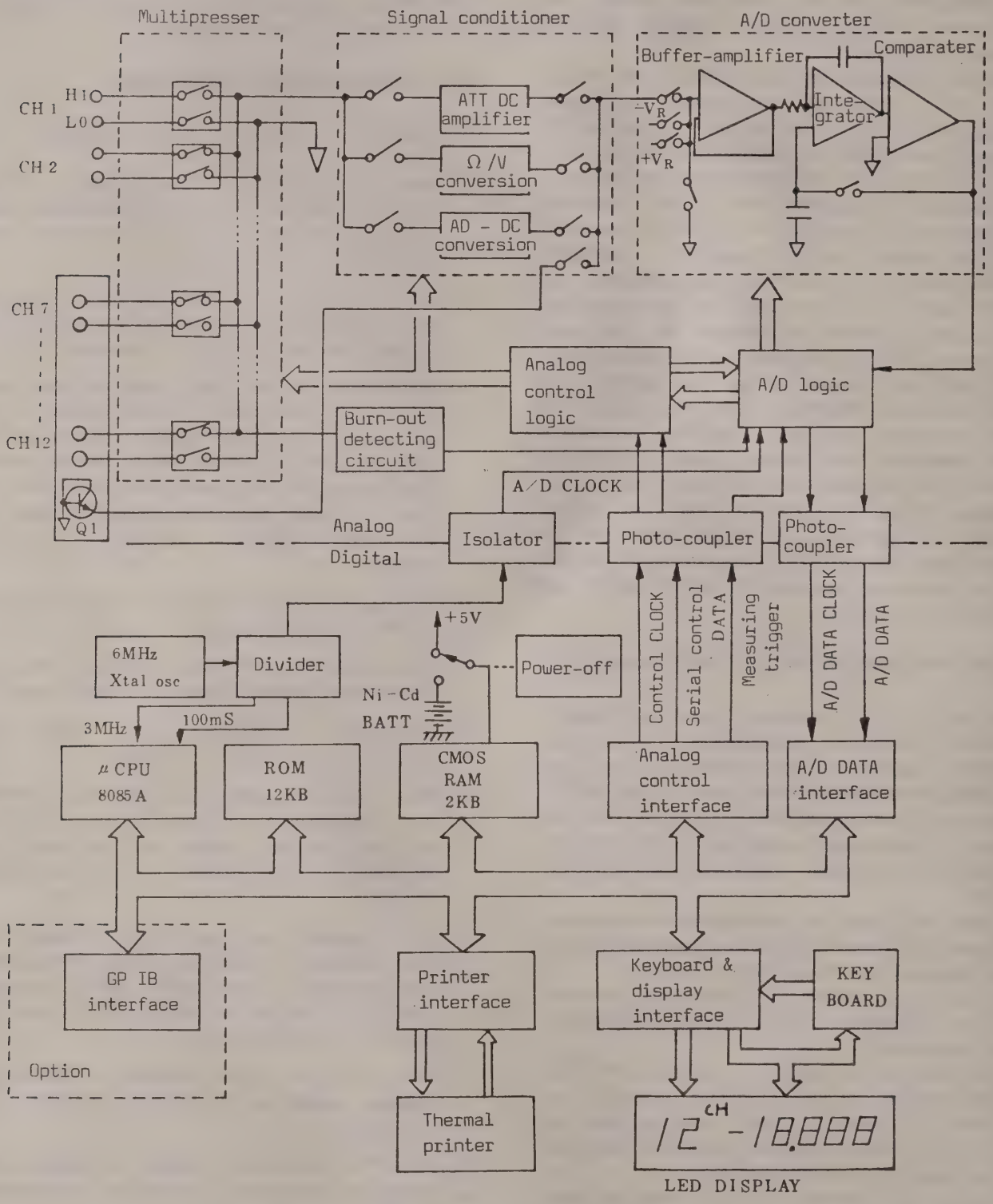
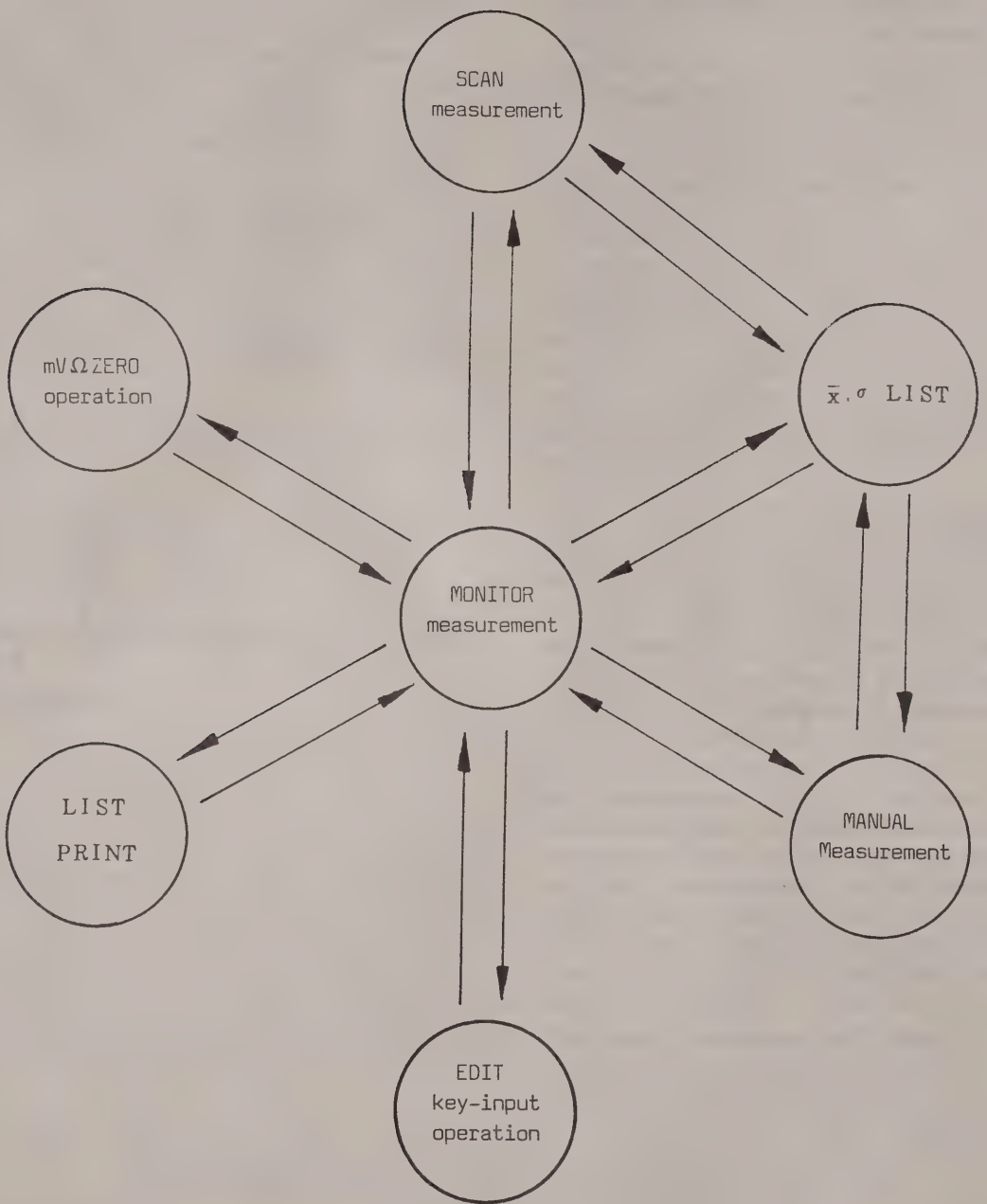


Figure 4-2 : Function Modes Viewing from the Aspect of Operation



4-4 PRINCIPLES OF TEMPERATURE MEASUREMENT

Figure 4-3 shows the thermocouple temperature measurement and reference point compensation circuits. The temperature measurement using the thermocouple is performed by measuring the difference in temperature based on some temperature, therefore, setting the reference temperature to 0°C equivalently enables the correct temperature measurement.

In Figure 4-3, when the temperature to be measured is t, and the terminal temperature is t_1, output of the thermocouple becomes E (t, t_1), provided that the temperature at a and b of the input terminal are sufficiently equivalent.

What to be measured is E (t, 0), and

$$E(t, 0) = E(t, t_1) + E(t, 0) \quad \ldots\ldots (1)$$

In order to measure E (t_1, 0), in this instrument, a transistor Q_1 arranged at the same temperature with that of the terminal is connected with the diode so as to measure the voltage thereof V_{BE}, and the terminal temperature t_1 is obtained arithmetically by the expression (2):

$$t_1 = C + D\,V_{BE} \quad \ldots\ldots (2)$$

wherein C and D are constants. From t_1, output voltage E (t_1, 0) which depends on the used thermocouple is obtained arithmetically.

ally in non-straight line to the temperature so that linearization is necessary.

In this instrument, linearization is performed by the broken line approximation, as shown in Figure 4-4. Number of the broken lines is 40 to 55 for each type of the thermocouple, and the data is stored in ROM. Conversion of the electromotive force (t, 0) of the thermocouple after reference point compensation into the temperature T is given by the expression (3), according to which uCPU performs the calculation.

$$T = T_n + \frac{T_{n+1} - T_n}{E_{n+1} - E_n} [E(t, 0) - E_n] \quad \ldots\ldots 3$$

In this expression, T_n, T_{n+1}, E_{n+1}, are constants approximated by JIS C1602 - 1981, and are stored in the read only memory ROM in this instrument.

Figure 4-4

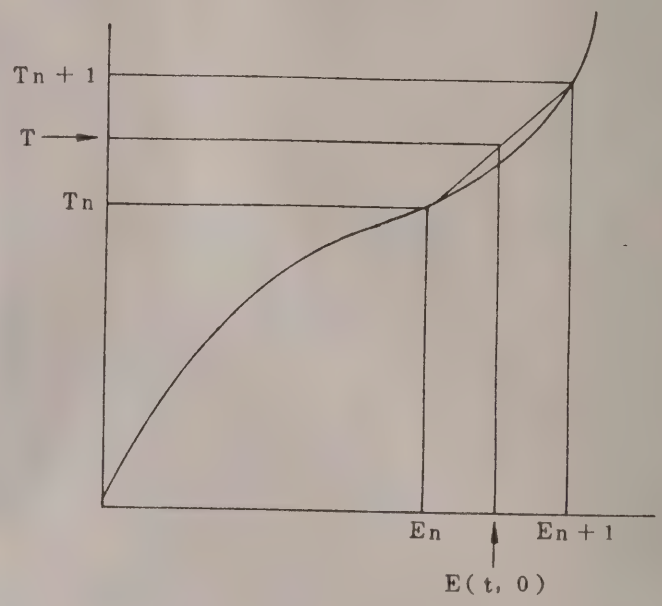
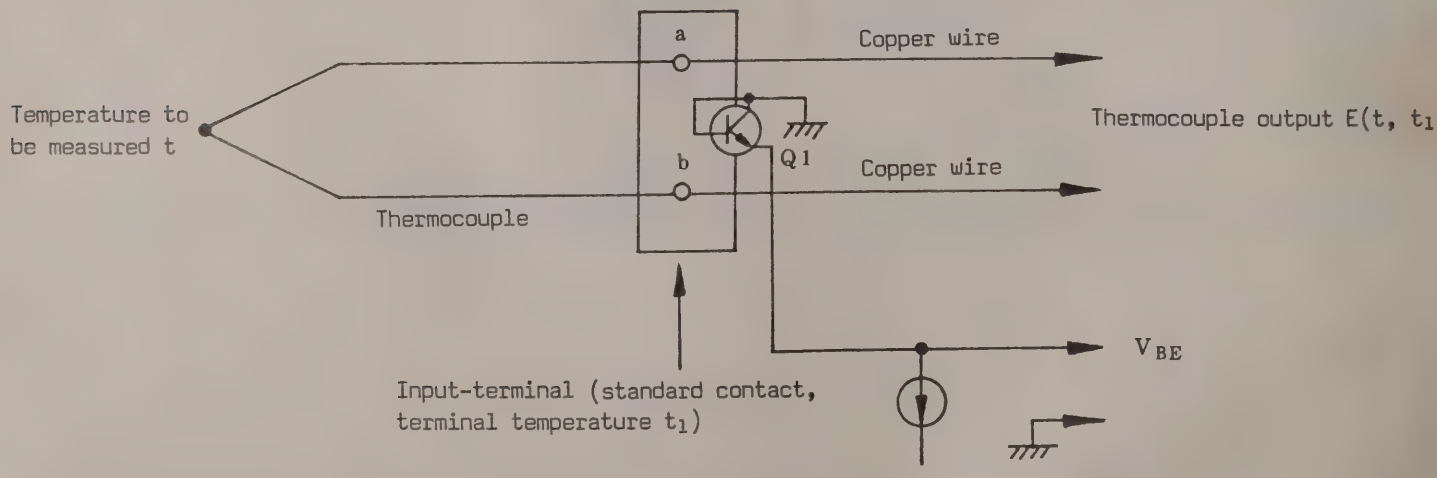


Figure 4-3 Circuit for Temperature Measurement and Standard Point Compensation



4-5 THERMOCOUPLES

Type of Thermocouples

There are seven types of thermocouples regulated in JIS (Japanese Industrial Standards): R, K(CA), E(CRC), J(IC), T(CC), B and S. (JIS C1602-1981) The termocouples are roughly divided into noble metal thermocouples and base metal thermocouples. As the noble metal thermocouples are made of high purity noble metals, they are characterized by the high precision and stability, and fit for use in accuracy measurements or as a temperature standard. In JIS, R, B, and S belong to this group. The base metal thermocouples have generally a larger thermo electromotive force and less expensive than the noble metal thermocouples, and so largely used in industrial measurements. Table 4-1 shows the type of main thermocouples, and measurable temperature ranges thereof.

Errors in Thermocouple Temperature Measurement

There are possible reasons for errors in the thermocouple temperature measurement as follows:

- Permissive errors of thermocouples
- Errors caused by connecting a compensating conductor.
- Instrumental errors

Following is an explanation of these errors.

Permissive errors of thermocouples:

Permissive errors of the thermocouples are regulated in JIS C1602-1981, as shown in Table 4-2. In addition, the stability of the thermal electromotive force is regulated as below 1/5 of the value in Table 4-2 in the difference before and after heating the thermocouple uniformly for 3 hours so that the whole length of the thermocouple is at a temperature within the normal limit in the air.

Errors caused by connecting a compensating conductor :

The compensating conductor is used as a material for extension of the thermocouple. As to the connection of the thermocouple with the compensation conductor, connect the + foot of the thermocouple with the + side core wire of the compensating conductor, while -foot with the -side core wire. Causing a difference in temperature between the two connecting portions or exceeding a fixed temperature range will increase the errors.

Errors of the compensating conductor is ±2.5°C (for J and E for general use and for thermal resistance in general rank), ±2°C (for T for general use, and for thermal resistance in general rank), or ±1.5°C for K in precision rank in the range of -20°C to +150°C, in accordance with JIS C1602 - 1981. (For further detail, see JIS C1602 - 1981).

Table 4-1 Type of Thermocouples

Type of Thermo-couples	Component Materials		Temperature Range	Merit	Demerit
	+ Foot	- Foot			
R	Platinum Rhodium (Rhodium 13%)	Platimum	0 to +1600°C	With good stability, usable at upto +1600°C	Linearity of heat electromotive force is poor. Delicate in the reducing atmosphere
K (CA)	Chromel	Alumel	-200 to +1200°C	Linearity of thermocouple is good. Measurable upto 1000°C. Strong against oxidizing atmosphere.	Delicate in a reducing gas. Changes slightly with the passage of time.
T (CC)	Copper	Constantan	-200 to + 350°C	With a relatively stable heat electromotive force. High accuracy at -70°C ~ +100°C. With reduction resistance.	Limited upto about 300°C
E(CRC)	Chromel	Constantan	-200 - + 800°C	Corrosion resistance and oxidation resistance are better than J(IC). Less expensive than K.	Delicate in a reducing gas.
J (IC)	Iron	Constantan	0°C - + 750°C	Strong against the reducing gases (H_2, CO, etc.).	Easily rust.

Instrumental errors :

The instrumental erorrs can be expressed by the standard contactor error and measurement precision. For these two errors, see Section 1 - Specification "Measuring Temperature".

Precautions on Thermocouple Temperature Measurement

Possible reasons for errors in the thermocouple temperature measurement may arise at various parts, and in order to minimize these errors, observe the following precautions:

Cautions

- Contact thermally the points on which the temperature is to be measured with the temperature measuring point of the thermocouple sufficiently.
- Thermal capacity of the temperature measuring point of the thermocouple should be enough small in relation to the thermal capacity of the measuring object.
- In the case of a sheath thermocouple, insert the sheath always in the fixed depth in the temperature measuring part.
- Do not expose the compensation point to the wind directly, and keep it at a normal temperature, or a temperature near that of the reference point. Also, avoid causing difference in temperature between + foot and - foot.
- Do not touch the reference point and the compensation point with a hand as far as possible. Otherwise, the temperature will rise, causing errors. If touched, take enough time to return it to the initial temperature before starting the measurement.
- In the case of a liquid temperature measurement, stir the liquid sufficiently so that the temperature distribution is uniform.

Table 4-2

Symbol of Component Material	Old Symbol (for reference)	Measuring Temperature Range	Rank (class)	Permissive Error (*)
B	——	600°C or more, less than 1700°C	0.5	±4°C or ±0.5% of the measured temperature
R S	——	0°C or more, less than 1600°C	0.25	±1.5°C or ±0.25% of the measured temperature
K	CA	0°C or more, less than 1000°C	0.4	±1.5°C or ±0.4% of the measured temperature
		0°C or more, less than 1200°C	0.75	±2.5°C or ±0.75% of the measured temperature
		-200°C or more, less than 0°C	1.5	±2.5°C or ±1.5% of the measured temperature
E	CRC	0°C or more, less than 800°C	0.4	±1.5°C or ±0.4% of the measured temperature
		0°C or more, less than 800°C	0.75	±2.5°C or ±0.75% of the measured temperature
		-200°C or more, less than 0°C	1.5	±2.5°C or ±1.5% of the measured temperature
J	IC	0°C or more, less than 750°C	0.4	±1.5°C or ±0.4% of the measured temperature
		0°C or more, less than 750°C	0.75	±2.5°C or ±0.75% of the measured temperature
T	CC	0°C or more, less than 350°C	0.4	±0.5°C or ±0.4% of the measured temperature
		0°C or more, less than 350°C	0.75	±1°C or ±0.75% of the measured temperature
		-200°C or more, less than 0°C	1.5	±1°C or ±1.5% of the measured temperature

(Note) : (*) The permissive error means the maximum limit permissive for the value obtained by subtracting the temperature of the measuring point from the temperature converted from the thermal electromotive force in accordance with the standard thermal electromotive force list. Also, the permissive error should be the larger value, either °C or %.

Section 5 CHECK AND ADJUSTMENT OF SPECIFICATIONS

In order to perform accurate measurement, each circuit of the multi-logger should operate normally, and its performane must be maintained always in good condition.
This instrument can hold a reliable performance for a long time by periodically checking and adjusting the performance. The methods for check and adjustment are described in this section.

5-1 PERIOD FOR CHECK AND ADJUSTMENT

Period for check and adjustment are required for the correct measurement, and every six months is suitable for this instrument.

5-2 CHECKING AND ADJUSTING ITEMS

There is a list of checking and adjusting items to be described in this section. Some of them are related to specifications on other items, therefore, be sure to check and adjust in the numerical as given below.

1. Check of power supply dc level
2. Check of frequency of the crystal oscillator.
3. Check and adjustment of backup battery.
4. Check and adjustment of dc voltage measurement.
5. Check and adjustment of ac voltage measurement.
6. Check and adjustment of resistance measurement.
7. Check and adjustment of temperature measurement.

5-3 PRECAUTIONS ON CHECK AND ADJUSTMENT

In executing the check and adjustment observe the following precautions:

- Set the ambient temperature to the normal temparature (+23°C ±5°C), and the humidity to 80% RH of less.
- Check the power supply AC line voltage, and warm up for about 30 min.
- Before starting the specification check and adjustment, check the power supply dc level of this instrument.
- Adjust only necessary reference designator, if limits for check are out. Do not touch others.
- Materials of the signal input terminal of this instrument are copper series. Connecting a lead-in wire of a different material (e.g. iron) will cause the heat electromotive force, therefore use the copper series one for the output cable (single output) of the standard. Errors may occur in check and adjustment in DC 20mV and 200mV ranges, and in full scale temperature measurement.
- Check only where reference designator is not described.

5-4 CHECK OF POWER SUPPLY DC LEVELS

Be sure to check the power supply dc level of this instrument before starting check and adjustment (see table 5-1).

Table 5-1 Power Supply dc levels

DC Level (V)	Voltage Range (V)	Check Point
+5	4.75 to 5.25	Between the cathode of D10 and the crystal case. See Figure 5-1.
-24	22.8 to 25.5	Between the collector of Q28 and the crystal case. See Figure 5-1.
+15	13.87 to 16.12	Between ⑩ and ⑧ on the pattern. See Figure 5-2.
+6.7	6.19 to 7.2	Between the cathode of D74 and ⑧ on the pattern. See Figure 5-2.
-7.8	-7.21 to -8.38	Between the anode of D75 and ⑧ on the pattern. See Figure 5-3.
-15	-13.87 to -16.12	Between ⑫ and ⑧ on the pattern. See Figure 5-2.

Figure 5-1 Adjusters and Test Points on Top

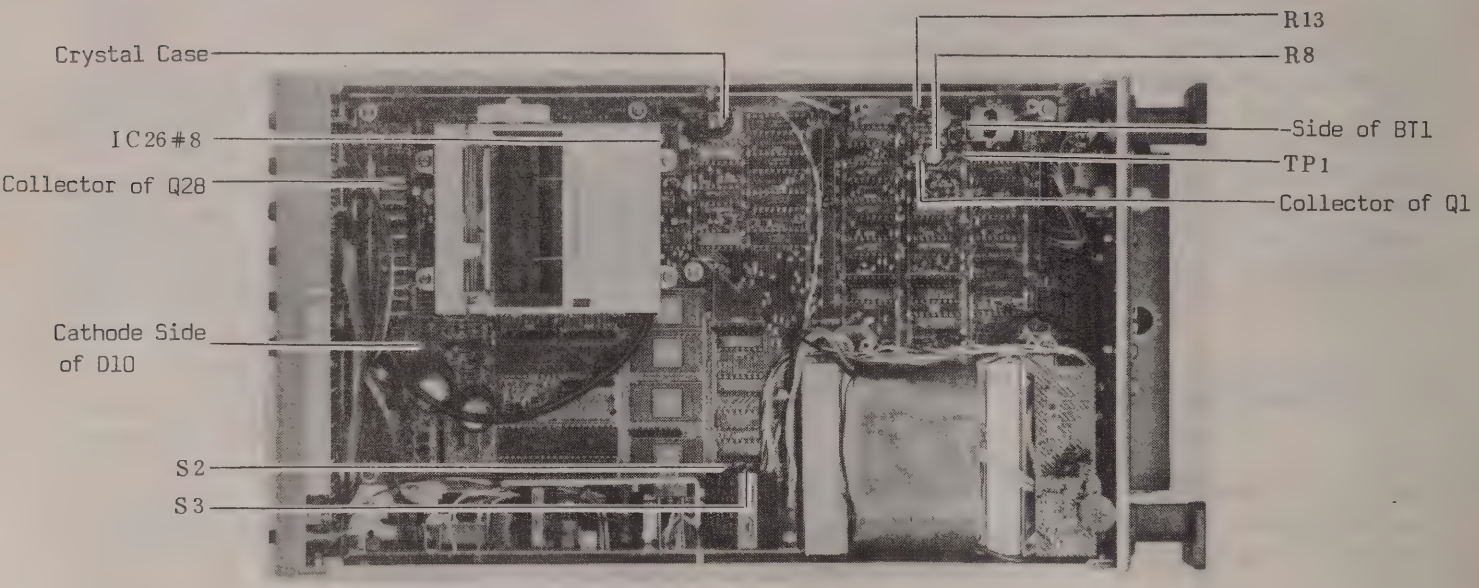
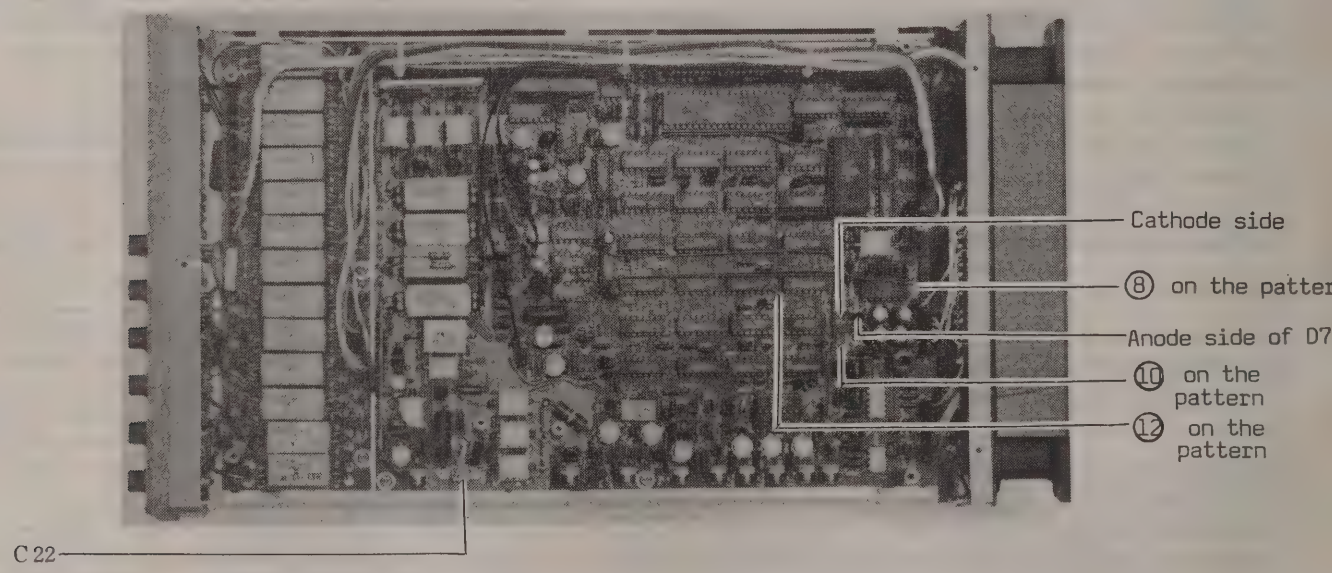


Figure 5-2 Test Points on Bottom



5-5 CHECK OF FREQUENCY OF CRYSTAL OSCILLATOR

Check the frequency of the standard oscillator.

1. Connect the frequency counter between the pin 8 of IC26 and the crystal case (ground) (see Figure 5-1).
2. Check that the display value of the frequency counter is 5.99950 MHz to 6.00040 MHz.

5-6 CHECK AND ADJUSTMENT OF BACK-UP BATTERY

1. Connect the digital multi-meter between TP1 and - side of BT1 (ground) (See Figure 5-1).
2. Check that the display value of the digital multi-meter is 0.795 V to 0.805 V.
3. If out of the rating, adjust R8 (see Figure 5-1).
4. Connect the digital multi-meter between the collector of Q1 and - side of BT1 (ground) (see Figure 5-1).
5. Check if the display value of the digital multi-meter is +3 V to +4.2 V when the power switch is turned off.
6. Following the above 5 steps, connect the digital multi-meter to the both ends of R13 (see Figure 5-1), and check that the display value is 23.0 mV or less (current 23 uA or less).

5-7 CHECK AND ADJUSTMENT OF DC VOLTAGE MEASUREMENT

Before starting the adjustment, turn on the POWER ON INIT switch on the rear panel, and turn off the power switch for about a second and then turn it on again. Therefore turn off the POWER ON INIT Switch.

1. Setting 20 mV range, short the input terminals HI and LO of CH1. Check then if the display value is as shown in Table 5-2.
2. If out of the rating, adjust R17 (see Figure 5-3).
3. Check and adjust of 2 V range (see Table 5-2).
4. Check and adjust 20 mV and 200 mV ranges (see Table 5-3).
5. Succeedingly, check and adjust in the order of 20 V, 200 V, and 270 V ranges (see Table 5-4).

Cautions

As to 2V range, independent reference designators are equipped for + input and - input, however, as to another range, + input and - input both should be adjusted by one reference designator. Accordingly, adjust that both + and - are within the rating.

Figure 5-3 Adjusters on Left Side

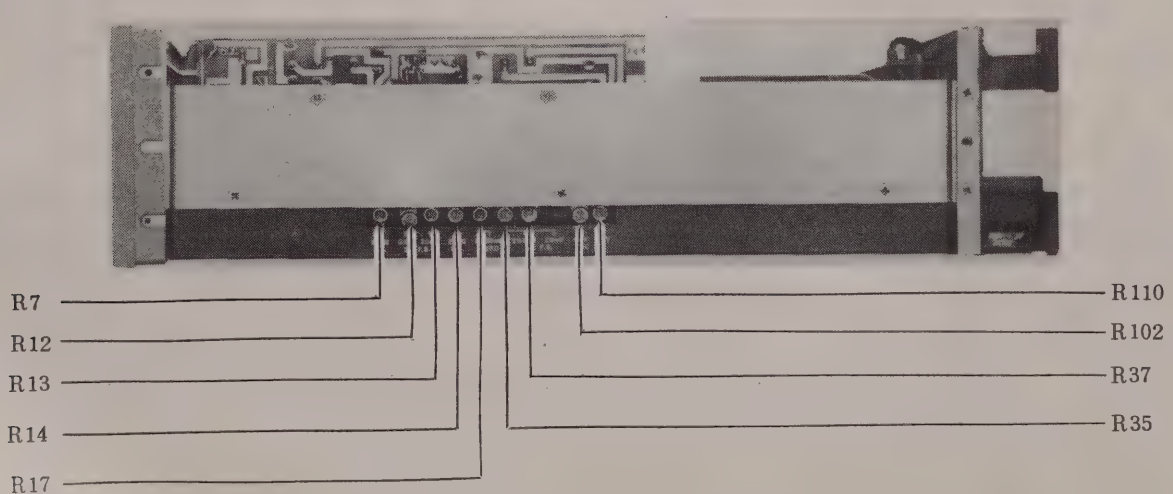


Table 5-2 DC 20 mV and 2V ranges

Range (V)	Calibrator Voltages (V)	Display Limits for Check	Display Limits for Adjustment	Reference Designator	Procedure
20m	Signal Input Terminal Short	±00.009	±00.001	R17	1
2	+1.9000	1.8993 to 1.9007	1.8999 to 1.9001	R110	2
	-1.9000	-1.8993 to -1.9007	-1.8999 to -1.9001	R102	3
	Signal Input Terminal Short	±0.0001	———	——	——
	+2.2	⊔⊔⊔⊔⊔	———	——	——
	-2.2	-⊔⊔⊔⊔⊔	———	——	——

Table 5-3 DC 20 mV, and 200 mV Ranges

Range (V)	Calibrator Voltages (V)	Display Limits for Check	Display Limits for Adjustment	Reference Designator	Procedure
20 m	+19.000	18.985 to 19.015	18.998 to 19.002	R37	4
	-19.000	-18.985 to -19.015	-18.998 to -19.002		
200m	+190.00	189.91 to 190.09	189.98 to 190.02	R35	5
	-190.00	-189.91 to -190.09	-189.98 to -190.02		
	Single Input Terminal Short	±000.03	———	———	———

Table 5-4 DC 20V, 200V and 270V Ranges

Range (V)	Calibrator Voltages (V)	Display Limits for Check	Display Limits for Adjsutment	Reference Designator	Procedure
20	+19.000	18.993 to 19.007	18.999 to 19.001	R2	6
	-19.000	-18.993 to -19.007	-18.999 to -19.001		
	Signal Input Terminal Short	±00.001	———	———	———
200	+190.00	189.93 to 190.07	189.99 to 190.01	R13	7
	-190.00	-189.93 to -190.07	-189.99 to -190.01		
	Signal Input Terminal Short	±000.01	———	———	———
270	+270.0	269.8 to 270.2	269.9 to 270.1	Check after adjustment of 20 kΩ range full scale	———
	-270.0	-269.8 to -270.2	-269.9 to -270.1		
	Signal Input Terminal Short	±0000.1	———	———	———

5-8 CHECK AND ADJUSTMENT OF AC VOLTAGE MEASUREMENT

Apply the caribrator voltage between HI and LO of the channel 1, and set the MONITOR CH to the channel 1 (see table 5-5).

Adjustment of Offset

The offset adjustment is performed as follows:

1. Set the AC V Switch to AC+DC. (Rear Panel)
2. Set the measuring range to 200 mV, and short the input terminals HI and LO of the channel 1.
3. Prepare DMM of direct current sensitivity 10 uV or more and input impedance 100 MΩ or more, and adjust reference designator at the test point (see Table 5-6).
4. Make A GND terminal on the rear panel as the GND of the dc level, and use a shield wire for the measuring cable.

Table 5-6

Test Point	Display limits (uV)	Reference Designator
TP 1	-400 to +400	R52
TP 2	-100 to 0	R72
TP 3	- 50 to + 50	R81
TP 4	- 50 to + 50	R88
TP 5	- 50 to + 50	R92

(As to the test point and the reference designator, see Figure 5-4.)

Table 5-5 AC Voltage

Rage	Function (V)	Calibrator Voltages (V)	Frequency (kHz)	Check Indication	Adjustment Indication	Reference Designator	Procedure
2 V	AC	1.0000	1	0.9940 to 1.0080	0.9999 to 1.0001	R85	1
	(AC+DC)	1.0000	1	0.9940 to 1.0080	——	——	——
200mV	AC	100.00m	1	099.40 to 100.60	99.99 to 100.01	R60	2
20 V	AC	10.000	1	09.940 to 10.050	9.999 to 10.001	R43	3
	AC	10.000	100	09.810 to 10.190	9.995 to 10.005	C21	4
200mV	AC	100.00m	10	099.40 to 100.60	——	——	——
	AC	100.00m	30	099.10 to 100.90			
	AC	100.00m	100	098.10 to 101.90			
2 V	AC	1.0000	10	0.9940 to 1.0060	——	——	——
	AC	1.0000	30	0.9910 to 1.0090			
	AC	1.0000	100	0.9810 to 1.0190			
20 V	AC	10.000	10	09.940 to 10.060	——	——	——
	AC	10.000	30	09.910 to 10.090			
200V	AC	100.00	10	099.40 to 100.60	——	——	——
	AC	100.00	30	099.10 to 100.90			
	AC	100.00	100	098.10 to 101.90			
270V	AC	270.0	1	0267.8 to 0272.2	——	——	——

perform the following offset adjustment and absolute value amplifier adjustment.

Adjustment of Absolute Value Amplifier

After completion of the offset adjustment, adjust the absolute value amplifier.

1. Set the function to AC+DC.
2. Set the measuring range to 2V.
3. Apply +1.0000V to the input terminal of the channel 1. Assume that the display value at this time is, for example, 1.0006.
4. Then, apply -1.0000V. Check that the display then is 0 ± 1 count (1.0006 ± 1 digit in the example of the step 3).
5. When it is not within the specified range, make an adjustment with R65. (See Figure 5-4.)

After adjustment of the offset and the absolute value amplifier, check and adjust again ac voltage measurement.

Check of Crest Factor

The crest factor is indicated as CF in the following explanation. Although the input signals used in the ac voltage measurement are all the sine wave (FC = 1.414), this instrument can measure signals other than the sine wave upto CF = 3.

Here, apply a signal of CF = 3 to this instrument with the connecting as illustrated in Figure 5-5 and make sure that the signal of CF = 3 can be measured.

First, set the square wave generator so that the repeating frequency is 1 kHz, and the duty ratio is 10 : 1. Then, connect the output of the square wave oscillator to the input terminal of the true rms value meter (AC coupling) and this instrument, and adjust the output level of the square wave oscillator so that the display value of the true rms value meter is 1.8000 (V). When the display is within the range indicated in Table 5-7, this instrument is operating normally.

Set this instrument in advance as follows:

Function : AC V (Rear Panel)
Measured Range : 2 V

Table 5-7

Duty Ratio	Display limit
10 : 1	1.7928 to 1.8072

Figure 5-5 Connection of Square Wave Generator with True rms Value Meter and This Instrument

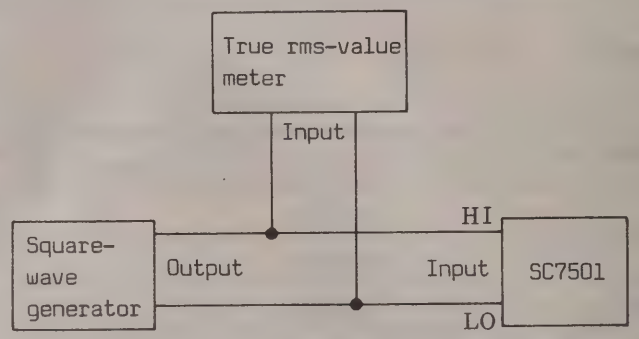
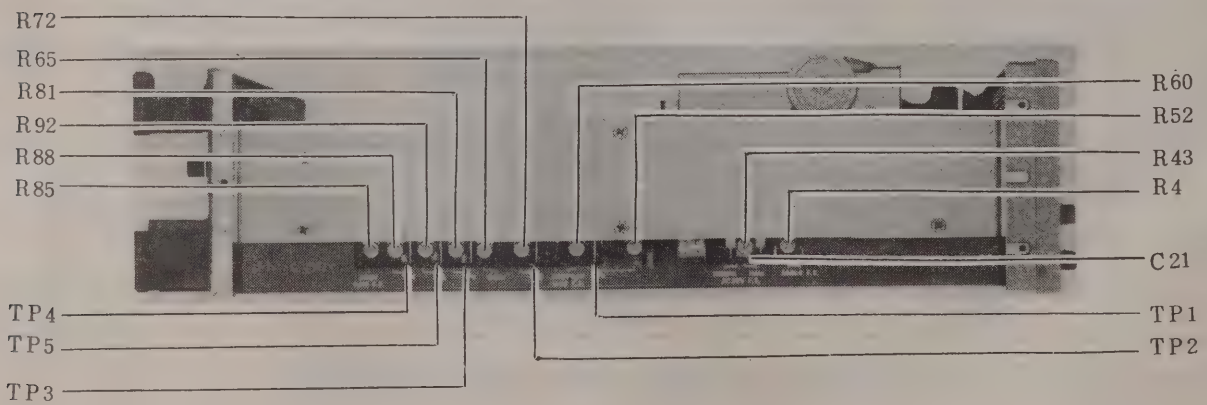


Figure 5-4 Adjusters and Test Points on the Left Side



5-9 CHECK AND ADJUSTMENT OF RESISTANCE MEASUREMENT

Check and adjust the resistance measurement procedure as described in Table 5-8.
See Figure 5-3 for the reference designator R7 and R14, and Figure 5-4 for R4 respectively.

Table 5-8 Check and Adjustment of Resistance Measurement

Range (Ω)	Calibrator Resistances (Ω)	Limits for Check	Limits for Adjustment	Reference Resignator	Procedure
200k	190.00k	189.91 to 190.09	189.99 to 190.1	R 4	1
20k	19.000k	18.991 to 19.009	18.999 to 19.01	R14	2
200 *1	19.00	189.88 to 190.12	189.99 to 190.1	R 7	3
	0	±000.04	———	——	——
20 *2	19.000	18.969 to 19.031	———	——	——
	0	±00.020			
	more than 20	⊔⊔⊔⊔⊔			
2k *1	1.9000k	18989 to 1.9011	———	——	——
	0	±0.0003			
2M *2	1.9000M	1.8984 to 1.9016	———	——	——
20M *2	19.000M	18.866 to 19.134	———	——	——

*1 In order to cancel the resistance of the input cable for measurement, short the tip end of the input lead-in wire securely and depress mV ZERO key before performing the check and adjustment. Therefore, the accuracy means after depressing mV ZERO key.

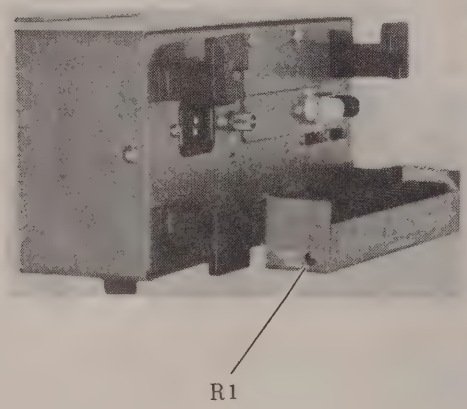
*2 Use a shield wire for the measuring cable in the measurement of 2 MΩ and 20 MΩ ranges, and do not touch the measuring cable with a hand, or do not allow it to dangle.

5-10 CHECK AND ADJUSTMENT OF TEMPERATURE MEASUREMENT

In the check and adjustment of temperature measurement, check and adjust the temperature zero point first.

1. Connect the thermocouple T(CC) to the input terminal CH9 on the rear panel. How to connect is explained in Section 2 : Operating Procedure "Input Terminal on Rear Panel". At this time connect the + foot (Cu) of the thermocouple to the input terminal HI and the - foot (C) to the LO.
2. After connecting the thermocouple to the terminal, be sure to put a cartridge cover on. Also, do not expose the input terminal to the wine. (This is for avoiding to cause the difference in temperature between the input terminals.)
3. Set the designated channel to CH9, the function to TEMP, and the measuring range to T respectively.
4. Connect each as shown in Figure 5-7. At this time, check if the display of the platinum resistance temperature detector digital thermometer is the same as the display of this instrument.
5. If out of, adjust R1 (see Figure 5-6). The rating is ±000.4°C.
6. Then, check the full scale and zero of the temperature measurement.
7. Connect the calibrator voltages to CH7 (rear panel), and inspect as follows:
8. Set S3 to ON side. (See Figure 5-1.)
9. Check as shown in Table 5-9. (Adjustment of full scale for each range has already performed in the step of the afore-mentioned "Check and adjustment of DC voltage Measurement", therefore, only the check is performed here.)
10. After the completion of check, return the S3 to OFF side.

Figure 5-6 Adjuster on the Rear Panel



Cautions

- As the temperature of the reference point is measured inside of this instrument once about 4 sec. in the monitor mode, wait for about 4 sec. after adjustment of R1, check the display.
- Check and adjust after 10 minutes or more since the thermocouple was connected to the input terminal on the rear panel.
- Check and adjust after 30 minutes or more since the tip end of each of the thermocouple and the platinum resistance temperature detector was inserted in the water.

Figure 5-7 Connection of the SC-7501 and Platinum Resistance Temperature Detector Digital Thermometer

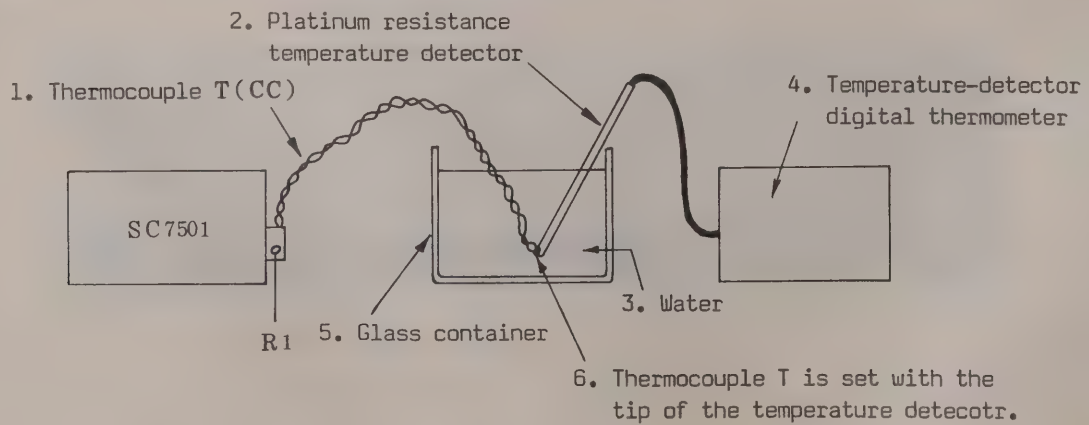


Table 5-9 Check of Temperature Measurement

Range	Calibrator Voltage (mV)	Center Temperature (°C)	Limits for Check
R	-1	- OVER	- OVER
	0	0	±3.6
	+4.471	+500.0	496.4 to 503.6
	+18.842	+1600.0	1596.4 to 1603.6
	+22.0	+ OVER	+ OVER
K (CA)	-5.891	-200.0	-198.2 to -201.8
	0	0	±2.3
	+20.640	+500.0	497.7 to 502.3
	+54.807	+1370.0	1367.7 to 1372.3
T (CC)	-5.603	-200.0	-198.9 to -201.1
	0	0	±0.9
	+4.277	+100.0	99.1 to 100.9
	+19.638	+380.0	379.1 to 380.9
J (IC)	-7.890	-200.0	-199.1 to -200.9
	0	0	±2.0
	+27.388	+500.0	498.0 to 502.0
	+51.875	+900.0	898.0 to 902.0
E (CRC)	-8.824	-200.0	-199.1 to -200.9
	0	0	±2.2
	+36.999	+500.0	497.8 to 502.2
	+76.358	+1000.0	997.8 to 1002.2

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